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ARTICLES

THE PRODUCTION AND UTILIZATION OF MILK SOLIDS IN AUSTRALIA

By G. LOFTUS HILLS

As far as can be discerned through the obscuring effect of recent droughts, total milk production in Australia is roughly the same as in 1938-39. Following a war-time decline, production has increased in the last seven years, but has in no way kept pace with increasing population and increasing demand. This condition of production, little better than static, is common to the dairy industries of several other countries, notably the United States and Canada. Total cow numbers are falling, mainly through abandonment of dairy production in the least suitable areas (in Australia these have been mainly in Queensland), while increases in efficiency of production elsewhere maintain or slightly increase the total.

Much the same might be said of agricultural production as a whole, but in a world of at least temporary increasing nominal leisure, the known time demands of dairy farming do seem to place this form of agricultural production in a particularly difficult position. Dairying has always seemed to be a "difficult" industry in the Australian economy—it has required the support of high home consumption prices, and more recently, of a government subsidy and guaranteed prices. No re-assessment of the role of the dairy industry in the Australian economy can be undertaken here, but it may be of some interest to attempt to answer in part the fundamental question: "Should we have a dairy industry at all, and if so, what form should it take?"

The nutritional aspect

The main argument in support of a dairy industry is the unique nutritive value of milk and dairy products. Combined with this is their attractiveness as foods. Apart from the prominence of milk products in our diet and the firmness with which food habits are held, the authorities on nutrition leave us in no doubt that liberal supplies of milk are necessary to the child and to the adult. For the adult, the simultaneous consumption of milk, with its high content of many essential food factors, permits the use of the cheaply produced but nutritionally unbalanced carbohydrate foods. There is as yet no substitute for milk either for this purpose or for the nutrition of the growing child.

Milk utilization

All the constituents of milk are not equally important from the dietary viewpoint, and all the milk solids produced in Australia are not used as human food. The form of milk utilization must therefore be considered if the value of dairy production is to be correctly assessed. If, for instance, 100 per cent. of the milk produced in Australia were farm separated and the cream made into butter, the dairy industry would contribute relatively little to dietary deficiencies. It is the skim milk constituents, the calcium

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salts, the high quality protein and the riboflavin which are particularly necessary in our diet.

Liquid milk and condensed and dried milk products make full use of the milk solids. Ice cream is nearly as good. With cheese, the fat and four fifths of the protein are used, but the lactose and one-third of the mineral salts are lost. Butter manufacture is most wasteful unless the milk is sent to the factory and the skim milk dried and used as human food. The present disposal of milk in Australia is 64 per cent. (mainly farm separated) to butter; 21.1 per cent. to liquid milk and ice cream; 8.1 per cent. to cheese and 6.7 per cent. to condensed and dried milk products. This means that 53 per cent. of the total milk solids go to human food. Of the other 47 per cent. perhaps one-tenth is needed for calf rearing and the remainder may, in a technical sense, be said to be wasted, since if fed to pigs only 8 per cent. of the protein and none of the calcium is returned. Having converted pasture to high quality human food, it is a most inefficient business to re-cycle it through another animal.

In the following table there are listed the approximate losses of each of the major milk constituents in Australia. For Great Britain and the other European countries figures are not available but something like 90 per cent. of the total milk solids would be fully utilized. Some figures for the United States are given in the table. Losses in the United States are lower than in Australia, but are nevertheless the cause of much official concern.

Constituent	Percentage lost from human consumption	
	U.S.A.	Australia
Butterfat	4.5	4.5
Lactose	46	72
Protein	39	64
Minerals	—	67
Riboflavin	—	70
Total solids	31	47

Factors affecting utilization

The completeness of milk utilization is governed both by the physical realities of the industry (distance of transport, size of herds, etc., which influence the economics of milk collection compared to cream collection) and by the imposed economic framework. Rationally this framework should be designed to foster the use of milk as liquid milk, milk products and ice cream, and to ensure that where butter is produced everything possible is done to encourage the drying of the skim milk. In fact, we find rather the reverse, with subsidies being paid on butter and cheese but not on liquid milk or on condensed and dried milks or on ice cream. Further, the latter is subject to a sales tax. If and when any action is taken to rationalize this position thought might be given to paying part of the subsidy to support the drying of skim milk.

One of the most effective ways of using the protein, mineral salts and riboflavin of milk as human food is to add dried skim milk to bread. The technical problems of adding milk solids to Australian bread are now solved. There remains, however, a great promotional task. The dairy industry must convince the consumer that the additional nutritive value of milk bread more than compensates for the extra ½d. per lb. which the bread will cost. With the known shortage of calcium in the Australian diet, and the now rather widespread realization of the deficiencies of water bread as a food, there is a splendid story to be put before the public. The dairy industry lacks any suitable organization to undertake this task.

Legislation and control

A suitable organization could not only do much to encourage this and other forms of use of non-fat milk solids, but could seek to correct legislation which impedes better milk solids utilization. In addition to the subsidies and sales tax anomalies, price-controllers have refused

to allow a special price for bread containing milk, and some State Pure Food Regulations require that dried skim milk be branded, in large letters: "Unfit for Infants". This must hinder any corresponding development here of the rapid growth in the use of low pre-heat spray dried skim milk in the home such as has taken place in the United States over the last three years.

Other desirable legislative amendments would be to permit the standardization of the fat content of liquid milk to say 3.5 per cent., releasing more fat for butter and giving a better beverage, especially for children. The undesirable aspect of this practice—that it increases rather than decreases the expensive water burden in the transport of milk solids as milk—might be overcome if at the same time the non-fat solids content was increased either by partial concentration or by the addition of low pre-heat dried skim milk. Standardization would require the payment for market milk on a butterfat basis—a most desirable move since, in our milk zones, as in Great Britain, purchase of milk on a volume basis is, through its long-term influence on breeding, bringing about a decrease in the solids content of milk.

One further obstacle to the better utilization of milk in Australia is divided control between liquid milk and other dairy products. Milk Boards in each state control liquid milk supplies. Other interests divert for manufacturing purposes milk requiring shorter transport. Prices are separately controlled. Unified control of liquid milk and dairy products is necessary if milk utilization is to be put on a more rational basis.

The soundness of the restriction of the manufacture of margarine by State legislation must also be re-examined if dairy production is to be soundly based. Vitamised margarine provides a less attractive spread for bread than good butter, but its nutritive value is high, and if locally grown oil seeds are used in its manufacture—and these might well be produced in part on dairy farms—there can be no valid objection to a reasonable expansion of margarine production.

Total production

The need to export

The problem of total production is even more important than the problem of milk utilization. On what basis should the desirable level of production be fixed? From the nutritive viewpoint it is clearly desirable to produce and correctly utilize enough milk solids to supply the needs of at least our own population. But this has not been the main determinant in government policy in the past. It is the need for exports which has led to government support in the way of subsidies and high local prices. Dairy products, in particular butter and cheese, have always commanded a market in Great Britain. While the price offering has usually been low, consecutive Australian governments have clearly deemed it reasonable to lose a little in order to continue using a natural resource in a way well suited to it, and a way which yields products readily sold overseas. The difficulty is to know where to draw the line.

In the past it has seemed that because it is possible to graze cattle throughout the year, so avoiding costly stall feeding, milk and dairy products may be produced as cheaply in Australia as in almost any country except New Zealand. We are now, however, facing a position in which net costs are forcing us out of the export market. The Commonwealth Government has placed a limit on the proportion of export butter which it is prepared to subsidise. Condensed milks, not now subsidized, and with 80 per cent. fixed costs, can no longer be produced at the export price. Dried milks are or will soon be in a similar position.

These higher costs have arisen in part because the dairy farmer has been

guaranteed a price covering his cost of production, in which his income and that of the labourer on his farm have been fixed at a rate comparable with that earned by the same level of endeavour in other industries. Is it that countries such as Holland and Denmark can produce more cheaply only because the dairy farmers are a relatively depressed class, as they were here in the 1930's? Have we created an entirely new position by bringing the average reward for the dairy farmer and his helpers to a reasonable level? The answers to these questions are clearly important in any assessment of the future role of the dairy industry in our economy.

Land use

Although they may be combined in a multitude of ways on different farms, there are only a limited number of forms of agricultural production. Of these the milking of dairy cows is one of the most widespread throughout the world. As a method of land use there is most to be said for dairy farming when, as in Australia, the cows are grazed on pasture. Not only is the use of animal-grazed pasture essential to the maintenance or improvement of soil fertility, but on much of our higher rainfall land, pasture is the most productive crop and the dairy cow the most practicable animal for making use of that pasture. Frequently the only alternatives are beef cattle or sheep. Sheep do not usually thrive under such conditions—a fact that has recently become clear to many of those farmers who, under the stimulus of high wool prices, gave up milking cows for raising sheep. Beef cattle require a larger area to provide a living for a farmer—evidence that they provide a less remunerative form of land use.

The efficiency of the dairy cow, in comparison with other forms of agriculture, as a producer of the various food constituents—carbohydrate, fat, protein, etc. —per unit of farm resources, was the subject of studies in the United States during the last war. These showed that as a means of converting pasture to animal protein the dairy cow came at the top of the list, and that as a source of calcium salts and riboflavin it was outstanding, exceeding the efficiency not only of other forms of animal production but of the food crops as well. On the other hand, as a source of fat, the dairy cow could not compete with the oil-seed crops. Such comparisons are incomplete because they take no account of the attractiveness of the foods for human consumption. Thus milk protein has not the attractiveness of grilled steak, while butterfat has flavour and physical qualities which still exceed the best efforts of the margarine chemist. But the picture is clear enough that, under United States conditions, the dairy cow must be regarded as a very efficient if not the most efficient means of converting pasture to high quality human food. Similar comparisons under Australian conditions might be of great value to the dairy industry here.

Dairy Farming as a Way of Life

In the depression years many of those unable to earn a livelihood by other means turned to dairy farming. From it they gained a living but little more. The standard of life on many farms was low. The conditions of that period, with barefoot children driving the cows in through the mud and doing the milking before they set out for school, still, to some extent, colours the common mental picture of the dairy farm.

The main reason why the reality is now, for the most part, so vastly different, is that high prices have reigned long enough to permit capital improvements. Both soil fertility and pastures have been improved. Milking machines and non-stripping have made milking a far simpler task. On the average dairy farm a good living can be made without pushing production to the maximum. The remaining disadvantage of dairy farming as a mode of life is that the cows must be milked twice a day 365 days a

year. There is nothing that can be done about milking twice a day, but there is increasing reason to believe that seasonal production may again become a common practice. The prospect of a one or two months' holiday from milking each year would do much to make dairy farming more attractive. Production might well be cheaper if allowed to follow the natural seasonal growth of pasture—certainly winter milk production for city supplies always incurs additional costs. With modern methods of conserving milk solids and reconstituting milk there is no technical obstacle to seasonal milking. Here again, however, there are legislative obstructions—the effective use of reconstitution to supply seasonal shortages requires that the addition of reconstituted milk to fresh milk be legalized.

Life on a company-operated or co-operatively grouped dairy farm must differ greatly from that on the privately-owned or share-tenanted farm. On a company-operated farm the staff would work a five- or six-day week in rotation. Co-operative grouping of dairy farms would also do away with the everyday aspect of milking. There are already moves of this type being made in the industry. In a reclaimed area in South Australia installation of a rotolactor has been suggested as a means of providing central milking facilities for a group of dairy farmers. In New Zealand a number of dairy farmers have co-operated to employ two workers to take over for holidays on a regular rotation, or in case of sickness.

While considerable development on these lines seems probable, an entirely different possibility cannot be overlooked. Increasing food shortages as well as the rapid strengthening of some unattractive features in modern city life may bring about a demand for land, even in small holdings, by present city dwellers. If this back-to-the-land movement does take an almost hunger-driven form, the matter of the attractiveness or otherwise of dairy farming becomes relatively unimportant—it seems certain that amongst the very intensive forms of land use which would accompany such a move, dairy farming would find a prominent place.

Conclusions

If any conclusions may reasonably be drawn from such a cursory consideration of the fundamentals of dairy production in Australia, they are somewhat as follows:—

(1) That Australia does require a dairy industry at least sufficient to supply her own nutritive needs.

(2) That better utilization of the milk solids produced is necessary, and that to achieve this (*a*) the imposed economic and legislative framework within which the industry operates must be re-examined and re-cast, and (*b*) an effective over-all dairy industry organization must be set up, probably on both a State and Commonwealth basis.

(3) That the efficiency of dairy production of food constituents in comparison with other forms of agriculture under Australian conditions might well be examined as part of a comprehensive reassessment of the role of the dairy industry in the Australian economy.

(4) That if an effective overall dairy industry organization is set up it should interest itself in, and undertake or support experiments in, forms of dairy production other than the privately-owned or share-tenanted dairy farm.

(*Received for publication August* 20, 1952.)

THE SIGNIFICANCE OF SULPHUR DEFICIENCY IN AUSTRALIAN SOILS

By A. J. ANDERSON

Introduction

Sulphur is an essential element for animals and plants. The importance in Australia of sulphur for animals, particularly for wool production, has been described by Marston and Brailsford Robertson (1928), and the role of sulphur in plants has been reviewed by Wood (1942). The effects of sulphur in the nitrogen metabolism of legumes and non-legumes has recently been compared (Anderson and Spencer 1950).

Sulphur deficiency in soils has long been recognised in other countries. The work in America has been reviewed by Alway (1940), Crocker (1945) and Gilbert (1951). American experience shows that sulphur deficiency occurs over a wide area in that country, and that legumes particularly are responsive to sulphur containing fertilizers. Responses to sulphur have also been recorded, especially on clover, in Russia (Prokoshev and Ustyuzhanina 1941), on sugar cane in Hawaii (Martin 1941), and on tea in Nyasaland (Forbes 1942).

Gilbert (1951) states that sulphur is seldom purchased to supply crop needs; it is applied unintentionally in superphosphate, ammonium sulphate and in mixed fertilizers, and is obtained gratis from the atmosphere in the form of sulphur dioxide.

The occurrence of sulphur deficiency in Australian soils

The occurrence of sulphur deficiency in Australian soils was first reported in 1949 (Anderson and Spencer 1949). This work was done in pot cultures using monocalcium phosphate as the source of phosphorus. Responses to sulphur occurred on all of the three soils, from the Southern Tablelands of New South Wales, used in the first experiment. One of the soils was from the C.S.I.R.O. Experiment Station, Canberra, one a very poor soil of sedimentary origin from Kingsdale near Goulburn, N.S.W., and the third a reddish-brown loam of basaltic origin from Roslyn, N.S.W.

The first evidence of sulphur deficiency in these experiments, which were done in 1948, was suggested by the marked response in colour and growth of the plants to a dressing of 5 cwt. of manganese sulphate per acre, and a similar response to ammonium sulphate as compared with nitric acid. A dressing of potassium sulphate applied at a late stage to some of the pots also improved the colour and growth of the plants. Final proof of sulphur deficiency was obtained in experiments which showed the similar response of plants to different forms of sulphur; the negative yield interaction between the different sulphates, the absence of response to corresponding chlorides, and the low sulphur content of the deficient plants (Anderson and Spencer 1949, 1950).

The results outlined demonstrate deficiency of the essential element sulphur, and are, of course, distinct from responses resulting from the effect of elemental sulphur on soil acidity.

The effects and interaction of sulphur and phosphorus on plants have subse-

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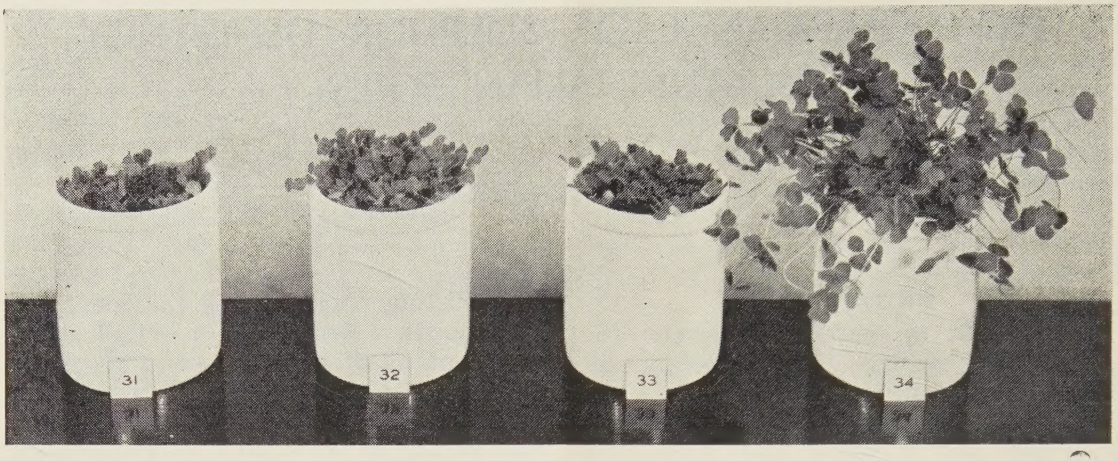

FIGURE 1.

Effects and interaction of phosphorus and sulphur on subterranean clover. (31) No S or P; (32) 2 cwt. sodium phosphate per acre; (33) ½ cwt. sodium sulphate per acre; (34) 2 cwt. sodium phosphate + ½ cwt. sodium sulphate per acre. The soil in the pots was from untreated land adjoining the property of Mr. H. F. Prell, in the Crookwell-Gouburn district, N.S.W.

quently been tested on four soils of different origin, from the Southern Tablelands of New South Wales (Anderson, unpublished data). Soils of sedimentary, basaltic and granitic origin were used in this work. On all soils marked responses to sulphur and phosphorus were obtained, and marked positive interactions between the two elements occurred. The responses to sulphur or phosphorus when applied alone were very small. Both had to be applied for normal growth (Figure 1).

Deficiency of sulphur has now been recorded on a soil of basaltic origin from the Darling Downs, south-east Queensland (Andrew, Kipps and Barford 1952), on a number of soils in Western Australia (Rossiter 1952) and on soils of basaltic and granitic origin on the Northern Tablelands of New South Wales (Davies 1951).

The importance of sulphur in superphosphate

Superphosphate was developed originally to provide a soluble source of phosphorus for plants, and has been regarded almost solely as a phosphatic fertilizer. This has been particularly true in Australia, where widespread phosphorus deficiency has long been recognised. However, the reaction between sulphuric acid and the tricalcium phosphate rock results also in the formation of gypsum, which constitutes about 50 per cent. of the superphosphate.

The effectiveness of the gypsum in superphosphate is indicated by general overseas experience. Sauchelli (1950) points out that superphosphate provides even more sulphur than phosphorus in a readily available form.

One of the soils from the Southern Tablelands of New South Wales used in the tests with sulphur and phosphorus was from untreated land adjoining the property of Mr. H. F. Prell in the Crookwell-Goulburn district. Both sulphur and phosphorus had to be applied before normal growth of clover could be obtained on this soil (Figure 1); but excellent clover has been developed on this country by Mr. Prell using superphosphate as the sole fertilizer. Had a phosphatic fertilizer lacking sulphur been used in this early developmental work, growth would almost certainly have been restricted by sulphur deficiency and it is even possible that the potential importance of subter-

ranean clover in the area would not have been recognised.

The results just quoted draw attention to the fact that any experiments designed to test superphosphate as a source of available phosphorus must take account also of the possible influence of sulphur in this fertilizer. For example, studies on phosphate fixation and on the residual effect of phosphorus cannot disregard the possible effect of sulphur when superphosphate is used.

Comparison of superphosphate with other phosphatic fertilizers must take account of the differences in sulphur content. Rock phosphate, and the newer phosphatic fertilizers such as triple super and silico-phosphate do not contain appreciable amounts of sulphur. It is possible that previously recorded failure of rock phosphate in comparison with superphosphate, particularly on pasture on acid soils, may have been due to deficiency of sulphur in the soil. Under these conditions even a soluble source of phosphorus may have been ineffective.

Triple super has been developed to provide a more concentrated phosphatic fertilizer than superphosphate. However, although sulphuric acid may be used as a step in the manufacture of triple super to produce the phosphoric acid, the final product does not contain sulphur. Sauchelli (1950) pointed out that the use of concentrated superphosphate would be likely to induce sulphur deficiency in many areas in America.

Comparison of deficiencies of sulphur and other elements in plants

The effect of superphosphate on the plants will vary depending upon whether the sulphur or the phosphorus is the major factor concerned in the response. Plants deficient in sulphur are pale green with a low percentage protein nitrogen, similar in many respects to plants deficient in nitrogen. By contrast, clover deficient in phosphorus is usually very dark green, with no evidence of nitrogen deficiency symptoms.

If the deficiency is one of sulphur rather than phosphorus, the quality of the feed is, therefore, very seriously impaired. Recent work (Anderson, unpublished data) shows that more sulphur is needed to maintain a maximum protein content in subterranean clover than is needed for maximum growth of the plants. In these experiments at least 0.1 per cent. sulphur was needed in the dry matter of the subterranean clover plant tops just prior to the flowering stage for maximum protein content.

Pale green plants on soils deficient in sulphur, but not in nitrogen, do not have a low percentage total nitrogen. Where nitrogen is not limiting, nitrate and other non-protein nitrogen compounds accumulate in the plant. Accumulated nitrate may be detected by a simple field test (Wark 1937). Pale green non-legumes in the field that do not contain higher concentrations of nitrate than normal are not likely to respond to sulphur, because of nitrogen deficiency. On the other hand, nodulated legumes low in nitrate will respond normally to sulphur on soils deficient in sulphur and nitrogen, as the nitrogen is provided through symbiotic nitrogen fixation.

On nitrogen deficient soils, clover deficient in sulphur is similar in appearance to clover deficient in molybdenum, with pale green leaves and low percentage nitrogen. However, whereas superphosphate improves the colour of sulphur deficient plants, it intensifies the nitrogen deficiency symptoms of molybdenum deficient plants.

Some general aspects of sulphur deficiency

A good deal of work has been done in America on the addition of sulphur to the soil in rain, on the leaching of sulphur from soils, and on the removal of sulphur by different crops. This work has been

reviewed by Lipman and Conybeare (1936) and others, and summarised by Crocker (1945), who points out that on an average United States soils contain about 60 per cent. as much sulphur as phosphorus. The sulphur is present largely in an organic form. On the whole, about the same amounts of sulphur and phosphorus are used by farm crops. Phosphorus is not leached from the soil but about 45 lb. of sulphur per acre is lost each year in this way. The accretion of sulphur to the soil in rain may be as little as 5 lb. per acre each year in rural regions and more than 100 lb. per acre each year near industrial and population centres. No phosphorus is added to the soil from the air. Deficiencies of sulphur occur in rural regions while deficiencies of phosphorus are general.

A general correlation between sulphur and organic matter content of soil has been shown (Anon. 1922). Sulfofication, a process corresponding to nitrification, has been studied (Starkey 1950) and Brown and Johnson (1916) found that the alkaline materials, calcium carbonate and magnesium carbonate, increase sulfofication in acid soils. On the other hand, Volk, Tidmore and Meadows (1945) found that lime increased the yield but decreased the percentage sulphur in the plants. In recent experiments on soils of the Southern Tablelands of New South Wales (Anderson, unpublished data), calcium and magnesium carbonates improved the colour and growth of plants as did sulphur, on sulphur deficient soils provided with nitrogen. This supports the suggestion that sulfofication as well as nitrification is increased by liming acid soils. It would appear that a most important source of sulphur for plants is that released by processes of sulfofication. Brown and Johnson (1916) found that a number of factors which influenced the nitrate content of soils similarly influenced the sulphate content, but the effects on the latter were less pronounced.

The evidence leaves little doubt that fallowing of the soil increases both the available sulphur and nitrogen. This may explain, for example, why high yields of crops can be obtained without superphosphate or other sulphur-containing fertilizers on fallowed land on soils of the Darling Downs, Queensland, even though it has been shown (Andrew, Kipps and Barford 1952) that plants grown on these soils in pot cultures may be extremely deficient in sulphur and nitrogen.

The evidence showing that comparatively large amounts of sulphur and negligible amounts of phosphorus may leach from soils suggests the possibility that under high rainfall conditions sulphur deficiency may develop more rapidly than phosphorus deficiency on land previously treated with superphosphate. However, it has been shown that a single initial application of superphosphate to pasture on the Southern Tablelands of New South Wales is as effective as correspondingly lighter annual dressings (Anderson and McLachlan 1951). No sulphur deficiency symptoms were apparent on any of the plants on these soils four years after the superphosphate was applied, even though at least one of the soils used in this work is very deficient in sulphur (Anderson, unpublished data).

McLachlan (1952) has reported an occurrence of sulphur deficiency in Australia on a soil in which phosphorus was not deficient. Similar results have also been obtained on certain soils in America (Reimer and Tartar 1919, Haddock and Vandecaveye 1945 and Conrad 1950). In that country gypsum has frequently been recommended for correcting deficiencies of sulphur. In view of the generally low phosphorus content of most Australian soils in comparison with soils of other countries, it is likely that phosphorus as well as sulphur will need to be applied in most cases where sulphur deficiency occurs.

Further work needs to be done to determine the particular conditions under which a sulphur-containing fertilizer such as gypsum might be used instead of superphosphate, and to determine whether the areas can be defined and practical recommendations made.

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REGIONAL LAND SURVEYS

By C. S. CHRISTIAN

The word "land" has many shades of meaning. But whether it be used in the broadest sense endowed with patriotic sentiments, or in a more personal, possessive manner, there is implied a summarization of numerous features of the earth's surface which influence its usefulness for the purpose in mind. It is in this comprehensive sense that the word is used in this paper rather than in the more restrictive sense adequately covered by the word soil.

Surveys dealing with the land of a region have been as varied in purpose and method as the many aspects of land itself. This paper describes a form of land survey developed in Australia in recent years by the Land Research and Regional Survey Section (formerly, the Northern Australia Regional Survey) of the Commonwealth Scientific and Industrial Research Organization. It is a method devised originally for broad-scale surveys of very large regions, with the object of determining development possibilities and providing a basis for further research. Consideration has been limited almost entirely to the use of land for primary industries.

The normal processes of exploration and pioneer occupation have resulted in the rural settlement of most accessible and easily developed parts of Australia. Where land and climate are favourable, and marketing facilities available, intensive settlement has taken place, but there are still some areas favoured by climate where more intensive settlement awaits the solution of soil fertility, crop production or pasture improvement problems. In distant or less favourable regions land use is on a more extensive scale and over much of the continent has not passed the stage of exploration or prospecting.

In the temperate regions of winter rainfall, agriculture has advanced into low rainfall areas and the sheep industry has intruded into the marginal lands of the semi-arid and arid zones. In the northerly parts of the continent, agriculture adapted to our standards of living has been restricted to the more favourable localities of the east coast. Apart from a few agricultural areas of insignificant magnitude the rural development of the remainder of northern and central Australia has been limited to extensive grazing of beef cattle, but even this form of land use has not effectively occupied either the monsoon areas of higher rainfall or the more arid interior.

In 1946, the Governments of the Commonwealth, Queensland and Western Australia formed the Northern Australia Development Committee with the object of formulating a policy of development for northern Australia. The committee early recognized the absence of adequate information about the nature of the lands and the climate necessary for the development of a sound policy. The Commonwealth Scientific and Industrial Research Organization was requested to initiate a series of land surveys of under-developed regions in order that their development potential might be more accurately assessed. In consequence the Northern Australia Regional Survey, established later as the Land Research and Regional Survey Section, was organized to conduct these regional surveys. This unit has now surveyed and mapped over 220,000 square miles of northern Australia.

The surveys posed two general problems: the first was to describe, classify

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and map the lands of large regions in relatively short periods of time; the second was to interpret land characteristics in terms of land-use potential.

Classification of Lands

Many forms of land classification have been adopted depending upon the particular purposes for which surveys are conducted. In this instance, in which the purpose is to provide a scientific basis for the present and future development of land, it is important that a fundamental classification should be adopted in order that it might be used not only as a guide to the application of knowledge at the present time but also as a permanent framework for additional investigations or applications in the future as knowledge of the possibilities of land use is increased by research in related fields. Such a classification should be independent of prevailing economic conditions but should be applicable to economic changes as they occur.

In regions where significant settlement has taken place it may be expanded by the extension of the existing forms of land use, with or without some modification, into adjacent or similar country. In such instances it is unnecessary to transport experience far from its place of origin and land surveys may have a well-defined objective of classifying land according to its suitability for known types of land-use. In under-developed regions such as these surveys are concerned with, where the pioneer agriculturalist has failed to overcome major difficulties of the environment, the probable forms of land-use are not clearly defined and may not be evident until the possibilities of finding solutions to technical problems have been determined. This is the position in much of northern and central Australia and is a further reason for a fundamental approach to land classification in land surveys of such regions.

Although the immediate potential of land is influenced by such factors as accessibility and the stage of development of the region as a whole, and although it may be modified by man through irrigation or cultural methods, each type of land has a basic potential for use which is determined by its more or less permanent qualities, that is, its inherent characteristics, and by climate.

The inherent land characteristics of most importance to land use are topography, soil and vegetation. These are the products of a long history of landscape formation.

Lands differ according to:—

(i) the material on which they are formed—the rocks and sediments of the region;

(ii) the processes and conditions which have operated to shape or modify these to form the present topography;

(iii) the soils, which are influenced by the parent material, the topography, the climate;

(iv) the naturally occurring vegetation adapted to the physical environment, the complex of topography, soils and climate.

A fundamental classification of lands must take into account all these factors and the work of the regional survey unit has thus included the study of geology, geomorphology, pedology, plant ecology and climatology of the regions surveyed. These studies have been co-ordinated in such a way as to permit the classification of lands into natural units differing both genetically and in their inherent land characteristics. The methods of land classification developed by the Land Research Section (Christian and Stewart 1952) are best described by reference to one of the completed regions.

The Barkly Region (Anon. in press) of the Northern Territory and Queensland comprises the area popularly known as the Barkly Tableland, the adjacent inland country and the coastal country between the tableland and the Gulf of Carpentaria. The region covers an area of

120,000 sq. miles and may be divided into the Barkly Basin, the Georgina Basin and the Gulf Fall, which are areas with separate and distinctive drainage systems.

Geomorphological Sub-Divisions

The land surface of each division may be classified into the following subdivisions:—

(*a*) a relatively stable flat to undulating land surface of Tertiary origin (Stable Land Surface);

(*b*) dissected areas in which erosion is actively carving a new land surface (Erosional Land Surface);

(*c*) areas in which deposition has been active at some stage since Miocene time (Depositional Land Surface).

Geomorphological Units

Further subdivision on a geomorphological basis is possible within each of these and the lands of the Barkly Region have been classified into twenty-one geomorphological units. A few examples will suffice to illustrate the nature of these units. The Tertiary land surface was characterized by large areas of gently undulating lateritized plain, areas covered by lakes and swamps, and inland areas of gently undulating plain that were not lateritized. Much of this land surface still persists as the Stable Land Surface, although the lakes and swamps are now mostly dry.

Warping of the land surface led to active dissection of the lateritic plain by coastal-flowing streams in the northern section and, on the steeper portion of the coastal slope, the removal of the lateritic horizon. The relic portions of the latericic plain at the top and at the base of the slope form distinctive geomorphological units referred to as the Tertiary Lateritic Plain and the Low Level Tertiary Lateritic Plain.

Distinctive alluvia were deposited in parts of the Tertiary lakes and limestones in other parts. The areas covered by these and the areas previously occupied by swamps form, respectively, the three geomorphological units: the Tertiary Lake Alluvia, the Tertiary Lake Limestone and the Tertiary Swamp.

The inland plains which were not lateritized, and portions of the lateritic plain where wind-blown calcareous material has accumulated on the surface, form two additional units, the Non-Lateritic Tertiary Plain and the Tertiary Plain with Aeolian Limestone.

The Erosional Land Surface and the Depositional Land Surface are likewise subdivided into a number of geomorphological units. The units within the former differ according to the nature of the surface, which has been eroded, and the extent to which the Stable Land Surface has been removed. The units of the Depositional Land Surface differ in their time of deposition, the nature of the deposits and the drainage system responsible for the deposition.

Land Units and Land Systems

The subdivision of a region into geomorphological units is a broad classification of lands based on genetic differences due in large part to the operation of different geomorphological processes. It usually follows that the inherent land characteristics of a unit are distinctive but variation within a unit occurs as a result of variation in parent material and differences in the stage to which a geomorphological process may have proceeded in various places. Further variation results from the range of climatic conditions which occurs within the area covered by a large unit.

This variation is expressed by changes in topography, soils and vegetation. In any one geomorphological unit it is possible to recognise distinctive and recurring units of topography with which are associated equally distinctive groupings of soils and vegetation. These have been termed "land units" and are the simplest units of country that a broad-scale survey can differentiate. Land units are associated in recognisable patterns which

are a product of certain landscape-forming processes operating on certain base materials. These patterns constitute land systems which have been defined as "an area, or groups of areas, throughout which there is a recurring pattern of topography, soils and vegetation." (Christian and Stewart 1952.)

One of the simplest types of land systems, consisting of two land units only, is the combination of levee and flood plain deposits of a small stream. Where such deposits extend for long distances along large rivers the nature of the soil and vegetation may vary markedly and several land systems may be recognisable. A more complex type of land system is represented by a maturely dissected area composed of several units such as steep strike slopes, less steep dip slopes, colluvial slopes, small areas of local alluviation and stream courses, each of the land units having characteristic soils and plant communities.

A geomorphological unit may contain one or more land system patterns. Where more than one is recognisable this may be a result of various factors; for example, in the Tertiary Swamp geomorphological unit of the Barkly Region which has been divided into four land systems, the Creswell and Barkly Land Systems are distinguished by differences in the nature of their soils and in the floristics of their grassland vegetations, associated with differences in rainfall. On the other hand, the Creswell and Joanundah Land Systems have very similar soils but the latter has a woodland vegetation. This difference between the land systems is mainly attributed to a difference in drainage status. The fourth land system which is geographically removed from the others has a much lower rainfall and differs from the others in both its soil and vegetation.

A somewhat different situation occurs in geomorphological units of the Erosional Land Surface. For example, in one of its geomorphological units three distinctive land systems have been produced by erosion of different geological parent material. In other instances the difference in pattern is explained by the stages to which erosion has proceeded.

In the Depositional Land Surface of this region many of the geomorphological units have only one land system. However, an interesting differentiation occurs in one of the units associated with the coastal streams. In this instance, two tributaries of the one river have eroded different kinds of rocks in their headwaters. The adjacent deposits, derived from these two sources, near the junction of the streams, have distinctive soils and vegetation giving two land systems with a sharp line of demarcation within the one alluvial plain.

The Regional Survey Unit

In order that the lands of a region may be adequately described, classified and mapped, specialist studies in many scientific fields are required. The Regional Survey Unit of the Land Research Section consists of a scientific leader, an ecologist, a geologist (seconded from the Commonwealth Bureau of Mineral Resources), a geomorphologist, a pedologist and a botanist, with technical assistants and non-scientific personnel, including a transport-supply officer, a mechanic, a cook and camp assistant. At the headquarters of the Section the survey unit has the co-operation of a climatologist and research staff concerned with the subsequent study of pasture and crop production in the regions surveyed.

The survey unit has its headquarters in Canberra where it works in close collaboration with the National Mapping Section of the Department of the Interior which produces the necessary base maps and prepares the maps made by the survey in their final form for publication. The co-operation of other authorities is received in the identification of botanical specimens, examination of geological specimens, analyses of soils and pasture samples and the processing and prepara-

tion of photographs taken for record and illustration purposes. The Royal Australian Air Force photographs the region surveyed from the air and produces the photographic prints required for field and laboratory work. Where a survey is conducted within a State territory the co-operation of State officers in field work is sought.

The survey unit, which spends three to five months of the year in field investigations and the remainder in the laboratory preparing reports and maps, is equipped for field use with vehicles, a mobile workshop, camping and messing equipment, medical supplies, a radio transceiver for communications and the necessary items of scientific equipment and supplies.

Survey Procedure

After a study of the available literature relating to the region to be surveyed, the first step in the survey programme is the preliminary examination of aerial photographs. These photographs, which are usually at a scale of 1:50,000 or 1:30,000, are laid as a mosaic so that large portions of the region may be studied at one time. Geological structures and drainage features are noted and a preliminary interpretation is made of the general geomorphological picture. Some general information on soils and vegetation may be obtained especially if the region is related to types of country previously surveyed. It is not possible at this stage to accurately identify different types of country. These are represented on the aerial photographs by differences in the pattern of light and shade which can be interpreted only by knowledge obtained on the ground. However, all types of country within the region, distinguished from one another by these photo patterns, are recorded, and land traverses are planned so as to obtain ground knowledge of each one for further photo interpretation. It is not practicable to examine every part of the region, but if the land traverses adequately sample every photo pattern in each of the geomorphological units it is possible to extend the photo interpretation from known areas to the remainder of the region with a high degree of accuracy.

The plan of field traverses is examined from the point of view of establishment of base camps, key points where fuel and other bulk supplies may be delivered, and the possibility of using existing roads and tracks. An itinerary is drawn up showing details of time allotted for operations from each base camp and on each traverse.

In the field the unit operates from the base camps for periods of one to ten days. Navigation is done by the use of base maps showing photo positions, the aerial photographs themselves, compass bearings, and speedometer mileages. When available a photo-copy of the photo-mosaic, at reduced scale, is used in addition to the base maps. About four to five thousand miles of land traverses are made each field season. The traverses follow the planned itinerary as closely as possible but are modified and added to where necessary and as additional field information is gained.

Continuous records are made throughout the traverses, special methods for the rapid recording of data having been developed in several fields; for example, a method based on the use of symbols and formulae has been evolved for the description of vegetation (Christian and Perry, in press). Speedometer readings between recognisable features on the aerial photographs are recorded for later reference. Frequent stops are made for the making of comprehensive records at selected sites and for the collection of plant, soil, geological and other specimens. Apart from the detailed information collected by each scientific officer in his own specialist field, particular attention is paid to the identification and description of geomorphological and land units and the recognition of land system patterns on the aerial photographs. This

information is recorded on the aerial photographs by the use of appropriate symbols. Recognisable boundaries actually encountered on the traverse routes are also marked and the traverse route is plotted.

On the return to headquarters each officer collates and summarizes the data in his particular field. The aerial photographs are re-examined and their interpretation is extended to cover the whole region. A final subdivision and classification of lands is determined and maps showing the geomorphological features and land systems are prepared.

The Assessment of Land Potential

The first phase of the regional survey, the description, classification and mapping of lands according to the principles described, is followed by an appraisal of the potentialities of the various land classes and possibilities of development within the region.

Past experience within the region may serve as a guide to the possibilities of land use but, as the regions surveyed are under-developed mainly because of inherent difficulties of the environment, relatively little assistance of this kind is available. In its absence, consideration must be paid to numerous factors which directly influence the possibilities of land use and development. These factors include accessibility, climatic conditions, water resources, including possibilities for irrigation, fertility and other characteristics of soils, and the nature of the vegetation especially the pasture and timber resources.

In most of northern and central Australia rainfall is a limiting factor either by virtue of the small amount received annually or because of its restricted incidence. An examination of rainfall conditions should permit demarcation of those areas that are suitable for particular purposes but there are limits to which present knowledge permits this to be done. Thus the more precise assessment of the value of the rainfall of an area has been made the subject of special study by the Land Research Section.

The major land mapping unit is the land system, which is composed of one or more land units. It is not possible to map the land units individually but the survey gives an approximate estimate of the relative proportions of each unit within a land system. If an assessment can be made of the land-use potential of each land unit a general indication of the usefulness of each land system is possible, and generalisations concerning the region may be drawn. Some land systems may be composed of land units of value only for pastoral purposes, at low or high stocking rates according to the type of pasture, or the climate. Others may include land units of agricultural value in small or large proportions and with varying crop potential.

The number of land systems in the regions surveyed ranges from twenty to forty. In order to simplify regional considerations these have been grouped in the later surveys according to their possible use so far as can be judged from present agricultural and pastoral knowledge. The groups of land systems having somewhat similar potential are called Land-Use Groups. Their number for a region is of the order of five to ten.

The assessment of the agricultural or pasture improvement possibilities of individual land units must be based on the application of existing knowledge of crop and pasture ecology and on comparisons with other regions with allied climates and soil conditions. There is a danger in the latter in that the social and economic conditions of other countries may not be acceptable and the fact that certain crops are grown in comparable regions elsewhere is not necessarily an indication that they could support settlement in northern Australia. In many instances further agronomic investigations are necessary before precise recommendations can be made, but one major contribution of these regional surveys is

TABLE I

Region	Area (sq. miles)	Number of Field Seasons	Number of Land Systems	Number of Land-Use Groups
Katherine-Darwin	27,000	1	19	—
Barkly	120,000	2	38	11
Townsville-Bowen	6,000	1	19	7
Ord-Victoria	70,000	2	to be completed in 1952.	

to indicate where effort might best be concentrated, that is on what forms of production and in what portions of the region. Thus from the survey of the Katherine-Darwin Region of the Northern Territory it was recommended that initial agricultural effort should be concentrated in the portion of the region mapped as the Tipperary Land System and that the possibilities of certain defined types of production should receive attention. The Katherine Research Station was subsequently established and its investigations have shown that with appropriate fertilizer and cultural treatments there is a reasonable chance of these being successful. Recommendations have been made that the results should now be applied on a farm scale and the establishment of an experiment farm has been commenced by the Northern Territory Administration.

Regions Surveyed and Further Applications

Since they were commenced in 1946 these surveys have covered four regions of northern Australia totalling more than 220,000 sq. miles. Table I gives the main features of these surveys.

The methods and procedure which have been outlined were developed for the survey of large regions in northern Australia. It would appear that the method has a much wider application and that its value is not restricted to undeveloped areas nor only to northern Australia. The main objective of this method is to produce fundamental information concerning those characteristics of regions which influence land use. This information is essential for proper planning and concentration of effort in undeveloped areas but it may have equal use in settled areas where a change in land use is desirable or necessary. The method described would provide basic information whether it be an undeveloped region in northern Australia, an intensively settled area in south-eastern Australia or a Pacific Island. Modification of actual procedure would be necessary according to the nature of the terrain but the general method and principles involved should be applicable irrespective of any difficulties met in practising them in particular areas.

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OBSERVATIONS ON ECOLOGICAL RESEARCH RELATING TO SOIL EROSION OF PASTURELANDS IN EASTERN NEW SOUTH WALES

By L. ELLISON

A New Cycle of Erosion

Gully erosion is widespread in the hilly country of New South Wales. ("Gully" in this paper means a channel incised into gentler topography by accelerated erosion.) One is impressed by the fact, repeatedly, in driving between the plains and the hills, that as soon as one encounters slopes, one encounters freshly-cut gully systems. The evidence is equally impressive from the air. To those who have seen pictures of devastated land in the Mediterranean region or extreme forms of erosion in parts of China, the gullying in New South Wales may not be very impressive. However, its importance derives not so much from the damage that has been done, so much as from its widespread occurrence, and from the fact that almost everywhere gullies occur, they are now actively cutting.

It seems quite clear that a new cycle of erosion has begun. This is to say that the erosion we see is not part of the age-long process that has been going on during the last several thousand years. It is certainly different in rate, being much faster, and it may even be different in kind. The evidence of change is written in the topography.

Firstly, shallow, gentle-contoured channels are seen to be incised by steep-walled gullies. However and whenever these shallow, broad-bottomed channels were formed—perhaps under present climate, perhaps in late Pleistocene, perhaps earlier — natural erosional processes under present climate have been, until recently, such as to lessen angularities and subdue relief. Now, however, erosional processes are of a kind to create angularities and intensify relief. Secondly, areas of aggradation, such as alluvial flats, are being actively degraded. A striking example is provided by alluvial fans at the base of the scarp along the west side of Lake George. Each of these toward the northern end of the lake is cut by a gully which, in many cases, terminates in a secondary fan below the original one. The first kind of evidence —gullies incised into shallow drainage channels—indicates either a sudden weakness of the sod in resisting cutting or a greater volume or velocity of water flowing over the surface nowadays than formerly. The second kind—incision of alluvia and their removal downslope, even though the stream is burdened with sedi-

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ment from new headwater gullies—indicates that the flow of water has been stepped up.

It is not the purpose here to fix the causes of this accelerated erosion, although one may be reasonably certain that it is post-settlement in origin. It must suffice to point out that the erosion we see is something new and different. This is a phase of the great problem of pasture development which is all-important to Australia, and is therefore something worth investigating further.

Research Problems

Soil

In Australia a good deal of emphasis has been laid upon soil formation in the remote past, and this emphasis has had the effect, one may suppose, of slighting soil formation in the present. At any rate, the idea seems rather prevalent that existing vegetation either does not affect the soil at all, or if it does, that its effects are slight. This notion may be correct, but it is more probably a natural result of oversight. Even though the effects of ancient climates are impressive, one is also impressed by an evident balance between soils as they exist today and the vegetation they support. This balance is not so dramatic as that which may be observed on steep mountain slopes in the United States; but it exists and should be recognised and understood. The ecologist has as much to do in achieving this recognition as the expert in soils.

The visitor is impressed with the shallowness and rockiness of soils where these have been formed under eucalypt forest. The rainfall in many places is very good —by standards formed in the western United States—but the soil is not. Is this situation simply a result of the weathering of parent rock which is very low in nutrient content, or is it a result of loss of nutrients during the weathering process itself? Granted that the present vegetation may reflect soils low in fertility, to what extent is the low fertility caused by this type of vegetation as a soil-forming agent?

What are the mechanics of this accelerated erosion? On pasture land, one does not find the finely dendritic pattern of rills and minor gullies combining to form large gullies that is so familiar on rangeland of the western United States and on clean-tilled farmland in many parts of the world. The gullies are generally stubby, each ending abruptly in a vertical wall. To what extent is it the result of a peculiarity of the soil profile, with a dense, massive, erosion-resistant, bleached layer lying above a looser structured, and erodible subsoil?

What are the effects on the soil of converting forest to grassland? Are there any appreciable differences now, after a century or more, between the two? What may the effects of improved pastures be on the soil profile? The bottom of the Canberra Basin and a number of low-lying areas between Canberra and Cooma are believed to have been grassland before the advent of the white man. If so, one would think they ought to have quite a different soil profile from that of the adjacent forest. Yet, as best one can make out without more detailed inspection, the soils are essentially the same. This observation seems incredible. Is it correct, and if so, what does that mean?

Topography

What is normal geologic erosion? A study of land forms should help in reaching a concept of its character and rate, which will perhaps permit distinguishing it from accelerated erosion.

The abrupt fault scarp lying west of Lake George provides one point of departure. As best one can judge from brief inspection, there is a wave-out terrace or beach at the base of this escarpment lying considerably above the present

high-water level of Lake George. This terrace runs out at the north into a spit or bar which the road traverses, and in the roadcuts here one can see water-worn gravel. It seems probable that these features relate to that part of the late pleistocene referred to as "Pluvial". Whatever its age, the fact is evident, particularly clearly in aerial photos, that the accumulation of alluvial material at the mouths of the various drainages is not very great as compared with the volume of material excavated from the drainages themselves. Their excavation had to take place after the uplift, of course, but it would appear that most of it took place before ancient Lake George was at its maximum. It would also appear that the old alluvia were worked over by the waves of the lake and distributed in the lake basin. The present alluvial fans therefore give some idea of the erosion that has taken place since the uplift, and if the above surmise is correct, in the 10,000 years (more or less) since the Pluvial.

Turning to another problem, a recent arid interval has been postulated (Crocker 1946); this being of such intensity in South Australia that the soil was stripped away and re-deposited in the form of dunes or sandsheets. If so drastic a climatic change did in fact take place, one might expect its effects to have influenced the vegetative, edaphic and hydrologic characteristics of the watershed catchment to the east appreciably, and one should expect to find evidence of this in the channel-cutting or depositional record of the streams. This suggestion is made, not only because the subject is one of intense interest in historical plant geography, but because the postulated catastrophe has no counterpart, so far as the writer is aware, in post-Pleistocene events in the northern hemisphere. There, essentially orderly adaptions to change are believed to have been the rule. This conclusion, incidentally, has had important application in land management in the United States.

Climate

The writer had the opportunity to observe the country between Griffith and Canberra from a plane after several days of soaking rain. The water seemed to be standing on the surface of the ground, or moving slowly down shallow drainageways, in a broad dark stain. Where a gully had eaten into the drainageway, the water spilled over in a little fall, and was actively at work, the gully channel being marked by a narrow yellow flood. The sharp contrast made dramatically obvious the fact that a new process was taking place. As to causes, it was clear that prolonged rain, probably not very intense, was sufficient to produce overland flow which was eating out the gullies, but it seemed unlikely from the uneroded drainages, that this amount of overland flow would have caused much cutting if the nick points at the gully heads had not already been established. Two questions arise from this:—

(1) What kind of storm was necessary to cause the initial gully cutting? Prolonged rains? Intense thunderstorms?

(2) Had the observed overland flow been increased by land-use practices—grazing, clearing, burning—or was it normal for that kind of storm?

To answer such questions, one needs to know the characteristics of rainfall for that country, the role of "exceptional" storms, what happens to the rain when it strikes the ground, and what happens to it in the soil. That it runs over the surface indicates that it cannot sink in: where is the barrier, at the surface or somewhere within the soil? Is this an unavoidable barrier, or is it affected by vegetation or land use?

Vegetation

There is no question but that vegetation protects the soil and that its removal

leads to accelerated erosion. Quite obviously, too, the cause of widespread accelerated erosion today is some factor or combination of factors that has disturbed the vegetal cover. Before effective control measures can be devised, these factors and the way in which they operate must be known.

What has been the effects of clearing? Clearing may have increased overland flow either by reducing the rate of infiltration or by removing a heavy drain on soil water. W. E. Abbott's observation on increased stream flow after ringbarking are pertinent to this latter point (Abbott 1881, 1888). Clearing may have had the opposite effect: it is quite possible that infiltration is more rapid under herbaceous cover than under forest. Differences in the amount of erosion between various properties suggest that other factors are more important than clearing, and one may observe gullies originating in eucalypt forest that appears to have been heavily grazed and trampled. Where there is a likelihood of erosion the effectiveness of different types of cover in promoting infiltration needs to be understood, and introduced pasture species should be evaluated in this way as well as with regard to forage value. Involved in such an understanding is the extent to which particular vegetal communities bind the soil and their effectiveness in shielding it from raindrop impact. The influence of clearing on the landslides that are so conspicuous near Picton, may well repay study. Observations in Queensland, suggest that relations between forest cover and landslides are more different than is generally believed. The relations may not be the same in the Picton area, however, where deep-rooted eucalypts, rather than shallow-rooted rain-forest trees have been cleared.

Fire

Observations in south-eastern Queensland on the behaviour of runoff during storms indicate that the effects of fire are profound. Clearly fire is a factor of the first importance because of its universality and because of the complete change in microenvironment it creates. There is a tremendous contrast in the reception of water on burnt and unburned ground, and rapid runoff from burned slopes probably contributes materially to flood peaks, particularly to those from high-intensity storms. The contrast in soil erosion is equally great, but it is not so dramatic. The more usually recognised indicators of erosion, rill patterns and gullies, are uncommon in this area. No soil movement was observed on unburned slopes, but after only moderate rains a multitude of tiny terraces where water had ponded behind little obstructions betrayed general displacement on burned slopes. Other indicators of soil movement were; exposed grass roots, short rills and raindrop "craters". Small individually, these little displacements must add up to a tremendous total in tons of soil moved because they were observed after every storm of beating rain and because of the great extent of land surface burned annually.

This erosion is deceptively inconspicuous, for, though widespread and probably vast in its proportions, it goes on practically unnoticed year after year. It does much to explain the shallowness of the soil profile under eucalypt forest. Probably, by promoting this sheet erosion, fire is more important than any other ecological factor under the control of man. Historically speaking and going back beyond the advent of the white man, one may reasonably suspect that fire has been just as responsible as climate in determining the composition and character of present vegetation.

Animals

Grazing by domestic livestock is one of the commonest causes of accelerated erosion elsewhere in the world, and is clearly one of the factors in Australia. Where grazing is demonstrated or sus-

pected as the cause, the question is, how may livestock be managed so as to minimize erosion or prevent it? Put another way, from the standpoint of soil protection, what is the difference between grazing and overgrazing? The effects of cropping on plant growth, on the litter residue, on stand composition, and the effects of trampling on soil density and structure, are all phases of the infiltration problem that should be considered. The existence of contour trenches shows that an erosion problem is recognised, but contour trenches are not necessarily a step forward in soil conservation. They are perhaps an admission of defeat, suggesting that cheaper measures of management have not been found which are adequate to solve the problem. Contour trenches are hardly a practicable solution on great areas of low-value land; there, the job must be done cheaply, by more and better vegetation.

Although these points and others that have been mentioned are of interest in themselves, their application to land use requires development of criteria by which the grazier can regulate grazing practices. Such criteria should include, beside indicators of accelerated erosion, standards of minimal plant cover and of plant composition.

One of the most difficult problems in assessing the results of grazing is that of distinguishing between the effects of livestock and of wild life. One may see land so denuded by rabbits as to cause accelerated erosion. It seems possible that kangaroos may occur in such numbers as to overgraze also, although no example of this has come to the writer's notice.

Ecologists, concerned with the entire environment must then not overlook the necessity for economic control of such agents of accelerated erosion if this latter is to be halted effectively.

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TECHNICAL PAPERS

THE EFFECT OF FERTILIZERS ON A WINTER WEED POPULATION

By L. F. MYERS and R. M. MOORE

Summary

A point quadrat analysis was made of a winter weed population on a citrus fertilizer experiment in which nitrogen, phosphorus, potassium, singly and in combinations, have been applied annually since 1924.

The principal effects of fertilizers on the botanical composition of the weed population were as follows. Capeweed (*Cryptostemma calendula* (L.) Druce), a major component of all plots, was the only species to show a marked increase on the nitrogen alone plots. Where nitrogen and phosphorus were applied together grasses were the principal species. Plots receiving phosphorus but no nitrogen consisted mainly of burr medic (*Medicago denticulata* Willd.). Potassium had no significant effect on the weed population.

The dominance of burr medic on plots receiving phosphorus alone for 24 years suggests a low soil nitrogen status under citrus. Although capeweed responded markedly to nitrogen, in the presence of both nitrogen and phosphorus, grasses competed successfully with capeweed. Grasses and burr medic did not occur together in quantity.

Introduction

A replicated 2 x 2 x 2 factorial experiment at the Irrigation Research Station, Griffith, New South Wales, designed to determine the response of Navel and Valencia oranges to applications of nitrogen, phosphorus and potassium has had treatments applied since 1924. Since the inception of the experiment 5.71 tons per acre of ammonium sulphate, 8.01 tons per acre of superphosphate (22 per cent. P_2O_5) and 19.7 tons per acre of potassium sulphate have been applied to plots receiving nitrogen, phosphorus and potassium respectively. The trees are planted on a 22-feet grid and each plot consists of two rows of four trees surrounded by a single guard row. Irrigations and cultivations cease at the end of summer and the area remains undisturbed until the following spring.

As striking differences were apparent in the volunteer winter weed populations of the various plots, a survey was made to determine the effects on botanical composition of fertilizers applied singly and in combination.

Methods

The botanical analysis was made between August 27 and September 3, 1948, with a point quadrat (Levy and Madden, 1933) having 10 points 10 cm. apart. Ten random quadrats (100 points) were taken in each plot in each of three positions; the bottom of the furrow, between furrows and on the tree line. Therefore the hits of 300 needles were recorded in each of the 32 plots (8 treatments x 4 replicates). The total number of hits, including the hits of each point in different storeys, was used as a measure of the contribution of the different species to the weed population.

Results

The total number of hits per 1,200 needles (300 per plot x 4 replications)

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TABLE I

Total number of "hits" per 1,200 needles recorded for each species in the 4 plots of each manurial treatment.

TREATMENT	Cryptostemma calendula (L.) Druce	Medicago denticulata Willd.	Avena fatua L.	Bromus catharticus Vahl.	Hordeum leporinum Link.	Poa annua L.	Lolium perenne L.	Erodium cicutarium (L.) L'Hérit.	Sonchus oleraceus L.	Lactuca scariola L.	Sisymbrium orientale L.	Euphorbia drummondii Boiss.	Capsella bursa-pastoris (L.) Medic.	Urtica urens L.	Cotula australis (Less.) Hook.	Malva parviflora L.	Miscellaneous
Control	745	188	6	70	89	66	6	6	22	4	5	2	3	0	2	0	4
Nitrogen	2033	2	11	9	26	129	2	28	7	0	5	2	0	0	0	0	0
Phosphate	751	1155	98	16	72	29	1	21	106	49	8	5	8	0	4	0	1
Potash	955	132	18	20	41	81	5	2	26	8	14	8	0	1	0	0	0
Nitrogen-phosphate	1163	71	190	301	967	294	0	114	91	2	2	10	1	34	2	17	1
Nitrogen-potash ..	1756	1	13	35	77	344	0	51	1	0	0	9	0	0	1	0	1
Phosphate-potash	822	1277	16	25	153	55	5	8	62	15	29	0	6	0	1	0	1
Nitrogen-phosphate-potash	1250	20	263	808	384	210	17	97	68	1	1	0	3	3	2	5	0
Totals	9575	2846	615	1284	1809	1208	36	327	383	79	64	36	21	38	12	22	8

recorded on each species for each manurial treatment is shown in Table I.

There was no consistent effect of sampling position on botanical composition; hence the data for furrow, interfurrow and tree line were grouped.

Reference to Table I shows that the principal species were capeweed (*Cryptostemma calendula*), burr medic (*Medicago denticulata*) and annual grasses such as wild oats (*Avena fatua*), barley grass (*Hordeum leporinum*), prairie grass (*Bromus catharticus*) and winter grass (*Poa annua*). Except for common crowfoot (*Erodium cicutarium*) and sowthistle (*Sonchus oleraceus*) which were most abundant on the nitrogen-phosphate and the phosphate plots respectively, the other species listed were too infrequent to show any effect from fertilizer treatment.

For a better comparison of the effects of nitrogen and phosphorus the data for the three principal species groups capeweed, burr medic and grasses (all species) have been listed separately in Table II. Since potassium, singly and in combination, had no significant effect on botanical composition the means have been included in the appropriate nil, nitrogen, phosphorus and nitrogen-phosphorus treatments.

As might be expected with volunteer species there was a marked variation within treatments, and therefore standard errors only of the treatments means were calculated.

From the tables it is evident that plots receiving nitrogen without phosphorus were high in capeweed but the grass population was not significantly different from the untreated controls. Capeweed was present on all plots; a minimum of 750 hits per 1,200 points was recorded on the controls and those phosphorus plots not receiving nitrogen.

In the presence of both nitrogen and phosphorus grasses were the principal components; burr medic was virtually absent and capeweed was less abundant than where nitrogen was applied alone. The reduction of the response of capeweed to nitrogen in the presence of phosphorus was due probably to competition from the high grass population. (Table II).

Burr medic predominated on plots treated with phosphorus alone; the amounts of capeweed and grasses were similar to the controls.

Nitrogen without phosphorus had little effect on grasses or burr medic except that, in comparison to the controls

TABLE II

Number of hits per 300 needles recorded for capeweed (Cryptostemma calendula), burr medic (Medicago denticulata) and grasses (all species). Means of 8 plots.

Treatments	Control	N	P	NP
Capeweed	217	474	204	302
Standard error of mean	±20	±46	±21	±38
Burr medic	40	0	304	11
Standard error of mean	±14		±55	± 6
Grasses (all species)	48	81	61	432
Standard error of mean	± 9	±36	±14	±72.5

which had a small quantity, burr medic was completely suppressed. Burr medic and annual grasses did not occur together in quantity.

Discussion

Where there are a number of species or species groups present in a population subject to different fertilizer treatments many factors are involved in determining the final botanical composition. Among the most important of these factors are, firstly, the effect of fertilizers on each species; secondly, the effect of this differential response to fertilizers on interspecific competition; and thirdly, the effect of previous populations on such factors as the nitrogen status of the soil. However, even when the response of each species alone to a fertilizer treatment is not known it is possible to draw some inferences.

The high burr medic counts on plots treated with phosphorus only for 24 years is noteworthy. It is known that annual grasses may invade old clover stands following an increase in the nitrogen status of the soil. The presence of citrus, a nitrogen-depleting crop, is presumably the factor responsible for the maintenance of legume dominance in this particular case. The fact that capeweed counts on the phosphorus only plots are of the same order as the controls may be due either to competition from the burr medic or to a lack of response of capeweed to phosphorus. The latter may imply a low phosphorus requirement and or limiting soil nitrogen.

The dominance of capeweed in the winter weed population where no fertilizers are applied, is increased by applications of nitrogen alone. However, where both nitrogen and phosphorus are applied, grasses predominate and the suggestion that grasses compete with capeweed presumably for nitrogen, seems a reasonable assumption. The alternative is that phosphorus in the presence of nitrogen has a direct depressing effect on capeweed, and this is unlikely.

Acknowledgments

The experiment on which the survey was made, was designed and supervised from its inception by E. S. West, Officer-in-Charge, C.S.I.R.O. Irrigation Research Station, Griffith, New South Wales.

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FACTORS AFFECTING THE USE OF A PROBE IN AN IRRIGATED SOIL

By A. L. TISDALL

Introduction

In irrigation practice it is essential to check the depth of water penetration if the maximum application efficiency is to be attained. Extension services both in Australia and the United States of America have for some years advocated the use of a probe for this purpose, on the assumption that this instrument gives an indication of the moisture content of the soil.

The probe is a half-inch diameter steel rod, about three feet long and marked in inches, and fitted at one end with a T-piece and handle. It is pushed into the soil by the operator using his maximum force (see Figure 1), and the depth of penetration into the soil is noted. Each reading takes only a matter of seconds and thus a great many replicate readings are possible. The probe has been mainly used immediately after irrigating when the depth to which it can be pushed into the soil has been taken as the depth of water penetration. That this is not correct in all circumstances becomes obvious when it is realised that the probe will penetrate most soils even in the dry state to at least some extent. Other factors such as the variation in force exerted and the physical condition of the soil will also affect probe depth.

It was considered that the information could still be valuable if probe depths could be shown to be related to soil moisture content. Accordingly an investigation was commenced to examine some of the factors involved. The soil type used for this work was Soil C, on Falkiner Memorial Field Station, Deniliquin, described by Butler and Johnston (1946) as a first stage hydromorphic variant of a Red Brown Earth. It has less than three inches of clay loam surface, with a medium clay compact-structured B horizon and a sandy clay C horizon. The slope is about 0.08 per cent.

Figure 1.
Showing the nature and method of use of the probe.

A. L. TISDALL, M.Ag.Sc., of the State Rivers and Water Supply Commission, Melbourne. The author was an officer of the Division of Plant Industry, C.S.I.R.O., when this paper was written.

Experimental Procedure

The first factor examined was the variation to be expected from operators exerting different forces.

During the course of field work on an experiment containing four replicates of nine treatments, an opportunity was made to compare probes by two operators. Each probe value was the mean of duplicates, and the total number of values obtained by each operator was 36. The operators weighed approximately 190 lb. and 140 lb. respectively, and the tests were made just before an irrigation. In this dry state probe depths would be at their minimum, but their variation could be expected to be at a maximum. The forces exerted by the two operators mentioned would be near the extremes encountered in practice; that exerted by an average operator would probably be between these two extremes. The mean probe depths recorded by the two operators were as follow:—

Operator	Approx. weight (lb.)	Mean probe depth (in.)
1	140	13.1
2	190	14.5

Mean difference in probe depth, 1.4 inches is significant ($P = 0.02$).

The second factor examined was soil moisture content.

A series of probes were taken on the field experiment discussed above. On each plot the mean of the values obtained by the same two operators was used, and the moisture contents of the first and second foot depths were determined gravimetrically on samples bulked from four one-inch soil cores. Means from the four replicated plots were then obtained, giving nine mean probe depths with corresponding soil moisture values. The procedure was carried out five times, and a wide range of moisture contents was covered. The probe depths varied from 5 to 23 inches, and the percentage soil moisture from 13.8 to 23.8 in the first foot, and from 12.6 to 25.2 in the second foot. There were 45 cases for use in the calculation of the correlation coefficients discussed below.

Results

Correlations

The correlation of probe depth with soil moisture was higher for the second foot ($r = 0.843$) than for the first foot ($r = 0.621$) but both were significant ($P < 0.01$). The multiple correlation ($R = 0.874$) gave further improvement in the estimate. The corresponding regression equation was:—

$$X = 1.2900Y + 0.3556Z - 14.925$$

where X = probe depth in inches
Y = percent. soil moisture in the second foot of soil
Z = percent soil moisture in the first foot of soil.

This regression was found to be valid for determinations both before and after wetting of the soil, that is, over the full range of soil moisture examined. Assuming a uniform moisture content in the first and second foot, then a probe depth of 11.5 inches corresponds to 16 percent., 18 inches to 20 percent., and 23 inches to 23 per cent. moisture for this soil type.

The relative importance of the second and first foot depth of soil in determining probe depth is given by the ratio of the regression coefficients. Thus the 1 to 2 foot level is 3.6 times as important as the 0 to 1 foot level, at least over the range considered in the data.

Estimation of Resistance to the Probe

In the above discussion, both the first and second foot of soil have been considered as having an influence on probe depth. But in fact quite a number of the probes into dry soil did not reach to a depth of one foot, and the analysis could be biassed for that reason. Consequently, an attempt was made to assess the relative resistance offered by the first and

second foot of soil to the probe. From the original probe depths, a soil moisture of 11 per cent. was arbitrarily taken as impenetrable and the resistance to the probe as proportional to $\frac{1}{M-11}$, where M = percent. soil moisture.

The resistance was equated to $\frac{ad_1}{M-11} + \frac{bd_2}{M-11}$ where d_1 and d_2 were the proportions of the first and second foot penetrated by the probes. The resistance may be taken as constant, that is, equal to the force exerted by the operator, and as unity since the coefficients a and b will be able to allow for the use of 1 in place of some other constant.

Solving the least squares equation gave the relation $\frac{b}{a} = 4.09$. Included in the 45 cases used were two probe depths of only 5 and 8 inches respectively. If these two are eliminated the relation becomes $\frac{b}{a} = 3.11$. The latter ratio is the fairer, as it could be expected that poor wall contact would be more important as the probe depth decreases. This ratio of 3.11 is the relative resistance of the second to the first foot, deriving from position only.

Conclusions

The experiments described gave the following results:—

(a) A small but significant difference in probe depths was obtained by two operators of different weight.

(b) Probe depths were highly correlated with soil moisture content under the conditions encountered.

(c) The second foot depth of soil appeared to be more than three times as important as the first foot in determining probe depth.

This work could be carried a step further, by taking soil moisture intervals of less than one foot down to the depth of penetration of the probe. The proportion of the resistance to be encountered at various depths could then be assessed. The tests could also be extended fairly easily on to a range of soils. The probe will not necessarily be of value in all conditions; for instance, there is a possibility that it may give erroneous results on heavy clays where the deeper subsoil tends to remain moist during the pasture irrigation season. It should also be emphasised that the resistance expression derived is quite arbitrary and may break down on other soils. It is not regarded as final, but illustrates a method of approach in assessing the relation.

Acknowledgments

The writer is indebted to Mr. G. A. McIntyre, Section of Mathematical Statistics, C.S.I.R.O., Canberra, for assistance with the statistical design and treatment, and to Mr. L. Collins, for help with the field work.

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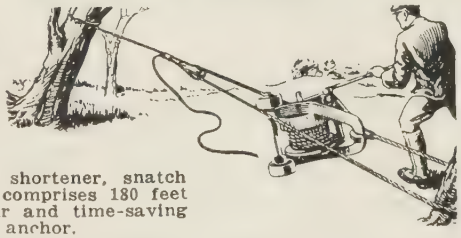

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RESPONSES OF SUBTERRANEAN CLOVER AND LUCERNE TO BORON

By A. J. ANDERSON

Summary

Responses of subterranean clover and lucerne to boron have been obtained in some experiments on the Southern Tablelands of New South Wales.

The residual effect of an initial dressing of 3½ lb. of borax per acre was still evident after six years.

On molybdenum deficient soil the response to boron was greater where molybdenum was applied.

Introduction

Field trials, of a 2^6 factorial design, were established in 1946 to test the effects of essential elements on pasture at the C.S.I.R.O. Experiment Station, Canberra, and in the Young, Boorowa, Crookwell and Goulburn districts of the Southern Tablelands of New South Wales. Responses of subterranean clover to molybdenum and a response to potash, which occurred in some of these experiments, were reported in 1948 (Anderson 1948). Responses of subterranean clover to boron, which have also occurred in some of the trials, are reported in this paper. In addition, responses of lucerne to boron obtained in an experiment begun at the C.S.I.R.O. Experiment Station in 1947, are also described.

Experimental

The experiments begun in 1946 each consisted of 64 plots. A 2^6 factorial combination of the following fertilizers was used:—

Borax—nil or 3½ lb./acre.
Molybdenum trioxide—nil or 2 oz./acre.
Copper sulphate—nil or 7 lb./acre.
Zinc sulphate—nil or 7 lb./acre.
Potassium sulphate—nil or 1 cwt./acre.
A mixture of elements—nil or a mixture of 56 lb. magnesium sulphate, 14 lb. manganese sulphate, and 14 lb. ferrous sulphate per acre.

All the fertilizer treatments were broadcast by hand at the beginning of the trials, in the autumn of 1946. A basal dressing of 3 cwt. of superphosphate per acre was applied to all plots in the same year, followed by 2 cwt. of superphosphate per acre in 1947, and 1 cwt. per acre in each subsequent year.

In the trials at the C.S.I.R.O. Experiment Station, Canberra, the fertilizers were broadcast on established pasture. At all other centres the fertilizers were raked into the soil with a seed mixture of 10 lb. of the Bacchus Marsh strain of subterranean clover (*Trifolium subterraneum* L.) and 3 lb. of phalaris (*Phalaris tuberosa* L.) per acre.

The experiment begun in 1947 on an established stand of lucerne (*Medicago sativa* L.) at Canberra had the same treatments as the experiment described above, except that the zinc sulphate was incorporated in the mixture with magnesium, manganese and iron, and did not occur separately. A single replication of the 2^5 factorial combination of treatments was used.

The treatments were applied with a basal dressing of 3 cwt. of superphosphate per acre on October 20, 1947. The lucerne was harvested on December 22, and again on February 9, 1948.

In all trials the plots were 15 x 20 links.

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Results

Responses of subterranean clover to boron

In 1947, a response of subterranean clover to boron, significant at the $P<0.05$ level, occurred in an experiment at Young. In subsequent years, responses to boron have occurred in some of the experiments at other centres on the Southern Tablelands of New South Wales. The results are shown in Tables I and II.

These responses were obtained on four sedimentary soils, as follows: at Young, on the property of F. H. Tout and Co.; at Murringo, on the property of F. H. Tout and Co.; at Laggan, on the property of Mr. H. Steel; and at Grabben Gullen, on the property of Mr. C. C. Hewitt. A response also occurred in a trial on soil which is probably derived mainly from diorite, on the property of Mr. J. C. Mason at Boorowa.

TABLE I

Effect of boron on the yield of subterranean clover at different localities on the Southern Tablelands of New South Wales.

Locality	Year	Dry matter per acre cwt.	
		Without Boron	With Boron
Young	1946		*
	1947	29.17	35.40†
	1948	31.59	30.49
	1949		*
Boorowa	1946	2.69	2.60
	1947	69.50	67.40
	1948	15.32	19.54†
	1949	2.29	2.60
Murringo	1946	0.95	0.91
	1947	14.00	12.59
	1948	35.13	33.77
	1949	28.19	33.32†
Laggan	1946	1.05	1.44
	1947	19.78	22.50
	1948	2.90	3.99‡
	1949	10.38	12.18‡

*Yields not determined.

†Increase significant at $P<0.05$.

‡Increase significant at $P<0.06$.

TABLE II

Effect of boron at varying levels of molybdenum on the yield of subterranean clover at Grabben Gullen.

Treatment	Dry matter per acre (cwt.)					
	1946	1947	1948	1949	1950	1951
Without B or Mo	0.49	1.97	6.41	2.69	7.75	5.13
With B	0.57	2.42	7.29	2.69	8.46	4.50
With Mo	0.40	2.85	9.66	11.32	18.18	11.79
With B + Mo	0.54	3.42	10.21	16.05*	25.84†	15.81†

*Effect of boron in presence of molybdenum significant at $P<0.05$.

†Effect of boron in presence of molybdenum significant at $P<0.01$.

At Young, the yield of clover was determined in 1947 and 1948 only. Here the response to boron occurred in 1947 but not in 1948 (Table I). At Boorowa, Murringo and Laggan, yields were determined in each of the four years 1946-1949. Responses to boron occurred at Boorowa in 1948, and at Murringo in 1949 (Table I). Responses to boron, almost significant at the $P<0.05$ level, occurred at Laggan in 1948 and 1949 (Table I). At Grabben Gullen, yields were determined in each of the six years 1946-1951, and responses to boron occurred in each of the last three years (Table II).

Effect of molybdenum on the response to boron

The boron-molybdenum interaction was significant at Grabben Gullen in 1951, at the $P<0.05$ level. The effect of boron at this centre in each year, in the presence and absence of applied molybdenum, is shown in Table II.

In the first three years boron had no significant effect on the yield in the presence or absence of molybdenum. In the last three years boron increased the yield of clover in the presence of molybdenum, but had little or no effect where molybdenum was not provided (Table II).

Responses of lucerne to boron

The effect of boron applied to an established stand of lucerne at the C.S.I.R.O. Experiment Station is shown in Table III.

TABLE III

Effect of boron on the yield of lucerne, nine and sixteen weeks after treatment at the C.S.I.R.O. Experiment Station, Canberra.

	Dry matter per acre cwt.	
	First Harvest	Second Harvest
Without Boron	15.7	19.1
With Boron	17.9*	26.1†

*Increase significant at $P<0.05$.

†Increase significant at $P<0.01$.

The yield of lucerne was increased by boron at both harvests. At the first harvest the effect was small, but at the second harvest there was an increase of 7 cwt. of dry matter per acre.

Discussion

The results show that deficiency of boron occurs in a number of soils on the Southern Tablelands of New South Wales, but that in most cases the deficiency is not severe. Responses of subterranean clover to boron were obtained on the three soils tested in the Boorowa-Young district, two of them of sedimentary origin, at Young and Murringo, and one probably derived mainly from diorite at Boorowa. Responses to boron also occurred at Laggan and Grabben Gullen, in two of the four experiments that have been established on soils of sedimentary origin in the Crookwell-Goulburn district. There has been no response to boron in the trials which were established on soils of granitic origin at Carrick and Tarago.

The lucerne which responded to boron was grown in a pure stand. Lucerne grown in a mixed pasture in an adjoining field did not respond to boron, possibly because of the restricted growth induced by the competition from subterranean clover and phalaris. Similarly, it is possible that the lack of response of subterranean clover to boron in the fourth year at Boorowa (Table I) was due to the poor growth of the clover, which in this year suffered severe competition from phalaris. However, in the experiment at Young (Table I) boron increased the yield of clover in 1947 and not in the following year, even though the clover grew well in both years.

In all the experiments boron was applied in the first year only. A substantial residual effect of an initial dressing of $3\frac{1}{2}$ lb. of borax per acre occurred, and appears to extend over at least six years.

The nature of the boron-molybdenum interaction, which was positive, was similar to interactions commonly obtained with two different essential elements. The response to boron was restricted under conditions of molybdenum deficiency, and full benefit was obtained only where the molybdenum was provided.

The soils on which the present responses to boron were obtained were all acid, within the range of pH 4.5 to 5.7. No lime was used in the experiments. It is likely that boron deficiency on these soils would be accentuated by liming, as lime has been reported to induce boron deficiency in other countries, both through its effect on soil pH and on calcium supply (Willis and Piland 1938; Eaton and Wilcox 1939; Parks and Shaw 1941; Askew 1946; Brennan and Shive 1948).

To the author's knowledge, response of subterranean clover to boron has not previously been reported. Boron deficiency in lucerne has frequently been reported in America (McLarty, Wilcox and Woodbridge 1937; Willis and Piland 1938; Powers 1939; Brown 1940). The condition is described there as "yellow top". In the present experiment boron deficiency was not sufficiently acute to induce any obvious symptoms on either the clover or lucerne. The boron content of the plants was not determined. Dawson and Gustafson (1945) found in field experiments that symptoms of boron de-

ficiency occurred on lucerne which contained less than 20 micrograms of boron per gram of oven-dry hay.

Marked responses to superphosphate have been obtained on all the soils where it has been tested on the Southern Tablelands of New South Wales. Other treatments are ineffective where insufficient superphosphate is used. The amounts of superphosphate needed are indicated in a previous publication (Anderson and McLachlan 1951). Experiments on the six soils where responses to boron were obtained have also shown responses to other treatments, viz., to molybdenum at Canberra and Boorowa (Anderson 1948); to lime and molybdenum at Grabben Gullen (Anderson and Moye 1952); and to lime at Murringo and Laggan (Anderson and Spencer 1948).

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DEPENDABLE PLANT PROTECTION PRODUCTS

TECHNICAL NOTES

NITRATE CONTENT AND TOXICITY OF QUEENSLAND PLANTS

Summary

Fifty-five species of flowering plants in Queensland reacted strongly to tests for nitrate. Seventeen of these species are known to contain other toxic principles in addition. It is suggested that the plants listed, which are liable to accumulate considerable nitrate, and which are eaten freely, may be responsible for death or for non-specific abortion in livestock.

Introduction

Williams and Hines (1940) showed that Mint Weed (*Salvia reflexa*) accumulates potassium nitrate in amounts sufficient to poison livestock which ate the plant freely. They suggested that in the drier parts of Queensland this toxic accumulation would be most likely after spring and early summer rains. The mechanism of poisoning, whereby nitrate is reduced to nitrite, *in vitro* or in the alimentary tract, and haemoglobin subsequently converted to methaemoglobin, with death by asphyxiation, was described. According to these authors, gross nitrate accumulation in some Queensland plants may be "a possible explanation of many obscure cases of plant poisoning".

More recent work in America (Gilbert *et al.* 1946; Davidson *et al.* 1941) confirmed the toxicity, under certain conditions, of a number of nitrate-containing plants. Factors shown to increase nitrate content, which is stressed as extremely variable, included shading, high available soil nitrogen, and a flush of growth. Spraying by 2,4-D weedkiller may also cause toxic accumulations of nitrate in plants, and investigations of the role of 2,4-D in this connection are required (Stahler and Whitehead 1950). Gilbert *et al.* (1946) also warned that ingestion of plants containing nitrate in sublethal quantities may cause abortion in cows and sheep due to asphyxiation of the foetus, remarking that "many unexplained cases of abortions, both in cattle and in sheep, might well be ascribed to this cause." For acute toxicity, the arbitrary figure of 1.5 percent. potassium nitrate in air-dried sample was fixed as the dividing line between toxic and non-toxic feeds. Quantities of nitrate lower than this figure were regarded as capable, after reduction to nitrite, of causing abortion, with few gross symptoms in the mother. Actual dosages were not specified.

According to McIntosh (undated, *ca.* 1949), diagnosis of nitrite poisoning can be based on the cyanide-like symptoms: "staggering, lack of convulsions, and the chocolate-brown colour of a syringe full of venous blood, or the colour of the blood in the surface vessels of the conjunctivae, all coupled with the feeding history."

In the course of a phytochemical survey undertaken by C.S.I.R.O. and the Australian universities, routine spot-tests have been made of several thousand species of flowering plants for alkaloids, saponins, pigments, cyanogenetic glycosides, and nitrates. For the latter tests, only herbs or shrubs likely to be accessible to livestock were selected.

Many cases of stock poisoning attributed to plants have occurred in Queensland, but with few exceptions, the active principles have not been identified. The phytochemical survey has provided the opportunity for co-operation with the

Queensland Poison Plants Committee, and toxic compounds such as alkaloids and oils, which require detailed analysis, have already been isolated from suspected plants. Where rapid spot-tests are available, as for cyanogenetic glycosides and nitrates, it has been practicable to offer preliminary chemical confirmation of alleged toxicity. This may help to clarify necessarily vague field information concerning some local poisonous plants. Results of tests for cyanogenetic and other compounds will be presented in another paper.

Method

A drop of 0.05 percent. solution of diphenylamine was brought in contact with sap expressed from the plant part (leaf, stem, or branchlet) on a white spotting tile. A dark blue colour (ranging from navy blue to almost black) was interpreted as a strongly positive test for nitrates. Weaker shades of blue were disregarded. In two cases (*Tribulus terrestris* and *Malva parviflora*) where strongly positive tests were obtained, subsequent analyses showed the presence of nitrate in excess of 4 percent. (dry weight basis). Nevertheless, no precise correlation exists between colour with diphenylamine and percentage of nitrate. Strongly positive qualitative tests provide circumstantial evidence only, which should be confirmed, where necessary in cases of stock poisoning, by quantitative nitrate analysis.

Discussion

A total of 589 plants was tested. Fifty-five plants, aerial parts of which gave strongly positive tests, are listed below in alphabetical order, together with month and locality collected. Species of *Amaranthus, Bromus, Chenopodium, Lactuca* and *Salsola* were previously shown by Gilbert *et al.* (1946) to contain over 1.5 percent. nitrate. *Malva parviflora* contained 5.1 percent. (dry weight basis) (W. R. Winks, personal communication). *Tribulus terrestris,* besides causing photosensitisation, has been shown to be responsible for nitrite poisoning in South Africa (Steyn 1934), and has been implicated in Australia, with symptoms resembling HCN or nitrite poisoning (Webb 1948). A recent sample of dried *Tribulus terrestris* contained 4.5 percent. nitrate (W. R. Winks, personal communication).

The qualitative results reported in this paper did not allow any deductions to be made concerning the extent of nitrate variation in local plants. Most of the positive species, however, were tested on different occasions from various localities, with similar results. Therefore, as is the case with other well-known plant accumulators (of aluminium, selenium, silicon, etc.), most of the species listed probably have a hereditary tendency for nitrate accumulation, although critical environmental factors will obviously affect the extent of this accumulation.

It is suggested that certain of the plants may, on occasion, be borne in mind by the veterinarian as possibly causing death or abortion due to nitrite poisoning. With the exception of *Antidesma, Atriplex, Bromus, Coldenia, Emilia, Millotia, Parkinsonia, Psoralea, Sigesbeckia* and *Spartothamnella,* all have been suspected of poisoning livestock in Australia. The symptomatology of plants such as *Malva parviflora* (causes "staggers"), *Salvia coccinea* (causes "abortion") and even *Euphorbia eremophila* (prussic acid symptoms, but prussic acid tests negative) agrees fairly well with that of nitrite poisoning. Moreover, as the symptoms of nitrite poisoning resemble those of prussic acid, some cases have probably occurred where prussic acid has been wrongly incriminated, e.g. *Silybum marianum,* (Webb 1948). In certain cases, potentially toxic compounds other than nitrate have been found—*Astragalus* (selenium); *Chenopodium, Eleusine* (prussic acid); *Aristolochia, Conium, Glaucium, Lactuca, Lithospermum, Lobelia, Nicotiana, Papaver* (alkaloids).

TABLE I

Species Strongly Reacting to Nitrate Tests.

Alternanthera denticulata	(Amaranthaceae)	Feb.	Stanthorpe
Amaranthus viridis	(Amaranthaceae)	Oct.	Brisbane
Ammi majus	(Umbelliferae)	Oct.	Warwick
Aneilema acuminatum	(Commelinaceae)	Mar.	Mt. Glorious
Antidesma erostre	(Euphorbiaceae)	Aug.	Atherton
Aristolochia deltantha?	(Aristolochiaceae)	Mar.	Babinda
Astragalus hamosus	(Leguminosae)	Sept.	Kingsthorpe
	(Queensland Herbarium (Q.H.) specimen 12 years old)		
Atriplex campanulata	(Chenopodiaceae)	Sept.	Bollon
A. spongiosa	(Chenopodiaceae)	Sept.	Bollon
Bassia bicornis	(Chenopodiaceae)	Sept.	Bollon
B. birchii	(Chenopodiaceae)	Sept.	Bollon
Bromus catharticus (B. unioloides)	(Gramineae)	Nov.	Brisbane
Centipeda thespidioides	(Compositae)	July	Cunnamulla
Chenopodium ambrosioides	(Chenopodiaceae)	Oct.	Warwick
C. murale	(Chenopodiaceae)	June	Thallon
C. triangulare?	(Chenopodiaceae)	July	Cunnamulla
Claoxylon australe	(Euphorbiaceae)	June	Imbil
Coldenia procumbens	(Boraginaceae)	?	Mitchell R.
	(Q.H. specimen about 6 years old)		
Conium maculatum	(Umbelliferae)	Oct.	Oakey
Ehretia membranifolia	(Boraginaceae)	June	Maxwelton
		June	Nonda
Eleusine indica	(Gramineae)	Oct.	Brisbane
Emilia sonchifolia	(Compositae)	June	Mackay
Euphorbia eremophila	(Euphorbiaceae)	June	Maxwelton
Glaucium corniculatum	(Papaveraceae)	Sept.	Baralaba
	(Q.H. specimen 4 years old)		
Gnaphalium purpureum	(Compositae)	June	Mackay
Heliotropium amplexicaule	(Boraginaceae)	Feb.	Stanthorpe
H. indicum	(Boraginaceae)	June	Mackay
Ipomoea calobra	(Convolvulaceae)	Oct.	St. George
Lactuca scariola	(Compositae)	Oct.	Brisbane
Lithospermum arvense	(Compositae)	Sept.	Kulpi
	(Q.H. specimen 20 years old)		
Lobelia purpurascens	(Lobeliaceae)	Mar.	Brisbane
Malva parviflora	(Malvaceae)	July	Toowoomba
Millotia greevesii	(Compositae)	Sept.	Bollon
Nicotiana gossei	(Solanaceae)	Dec.	Dajarra
N. megalosiphon	(Solanaceae)	Oct.	Jandowae
N. velutina	(Solanaceae)	Sept.	St. George
Papaver aculeatum	(Papaveraceae)	Oct.	Mundubbera
		Nov.	Kyogle
	(Q.H. specimen 5 years old)		

TABLE I (*contd.*)

Species Strongly Reacting to Nitrate Tests.

Parkinsonia aculeata	(Leguminosae)	?	Longreach
Parsonsia lilacina	(Apocynaceae)	Oct.	Mt. Glorious
Physalis minima	(Solanaceae)	June	Boonah
Psoralea cinerea	(Leguminosae)	July	Cunnamulla
Salsola kali	(Chenopodiaceae)	June	Maxwelton
		Sept.	Bollon
Salvia coccinea	(Labiatae)	Oct.	Mulgeldie
S. reflexa	(Labiatae)	Jan.	Gatton
Sigesbeckia orientalis	(Compositae)	Feb.	Brookfield
		June	Boonah
Sonchus oleraceus	(Compositae)	Dec.	Brisbane
Spartothamnella juncea	(Verbenaceae)	Oct.	Dalby
Threlkeldia proceriflora	(Chenopodiaceae)	June	Maxwelton
Trianthema decandra	(Aizoaceae)	June	Nonda
Tribulus astrocarpus	(Zygophyllaceae)	June	Windorah
T. terrestris	(Zygophyllaceae)	Mar.	Crow's Nest
Verbesina encelioides	(Compositae)	Apr.	Gatton
		(Stem, not leaf)	
Vittadinia triloba	(Compositae)	July	Cunnamulla
Wedelia asperrima	(Compositae)	May	Oorindi
	(Q.H. specimen 20 years old)		
Zygophyllum apiculatum	(Zygophyllaceae)	Apr.	St. George
		June	Maxwelton

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INSTITUTE AFFAIRS

NINETEENTH GENERAL MEETING

The Nineteenth General Meeting was held at Science House, Sydney, on August 18 *and* 19, 1952. *There was an afternoon session on August* 18, *and a morning and afternoon session on August* 19, *followed by the Institute Dinner and Presidential Address. In addition to members of the N.S.W. Branch and interstate visitors there were in attendance the President, delegates from all branches except Tasmania, the Honorary Business Manager and the Honorary General Secretary.*

In the first business session, after the usual formalities there was a lengthy discussion on the various consequences of the changes inaugerated at the Brisbane meeting. The interchange of branch views on useful activities at the branch level was instructive. The Business Manager outlined the financial position of the Journal and the steps which had been taken to decrease the cost of production by increasing circulation and by advertising. It was considered premature to reach a decision on the value of two delegate-in-person meetings per annum and that a review could suitably be made at the next annual general meeting. A statement prepared by Mr. G. H. Vasey on the position of agricultural engineering overseas and his views on future Institute action on this matter was read by Mr. L. R. Hoult. The statement was received and referred to branches for consideration and the thanks of the Institute to Mr. Vasey was expressed.

In the second session, an amendment of the Articles to create a class of affiliates was carried by a narrow majority. There was a move to request a postal vote on the carried motion but this has been withdrawn pending discussion between the delegate and his branch. The intent of the Article governing this procedure is not clear and legal opinion may be sought. A discussion on the deletion of Article 4 (iii) covered familiar ground. An amendment on these lines by the West Australian Branch is forecast for the next general meeting. A motion put forward by the Victorian Branch to investigate the feasibility of establishing a central secretariat was accepted. The meeting resolved that a central committee comprising members associated with training and departmental services should be formed to carry through the third stage of formulating the ideal in rural extension services, namely, pre- and in-training. In view of the difficulties associated with the collection of funds for the proposed scholarship scheme, the unacceptibility of scholarships in the honours year for taxation exemption to donors and the present surplus of postgraduate scholarships, it was decided not to proceed further with the scheme. It was resolved that a further request be made to the Commonwealth Office of Education to consider increased emoluments to honours students. The memorandum on formation of Institute Opinion by the treasurer and secretary was adopted.

In the third session it was uniformly agreed that there was little prospect of support for an A.I.A.S. convention by State and Commonwealth Governments, various factors making the present position much less favourable than in 1948. It was decided to examine the possibility of a joint session of an A.I.A.S. technical convention with Section K of A.N.Z.A.A.S. Exploration of the possibility of F.A.O. meeting the expenses of an overseas visitor to lead discussion of public meetings on food production arranged by branches was recommended. Examination in more detail of the suggestion for a general text book at agricultural college and farmer level and sponsored by the Institute, was supported. It was agreed that the office of management should be transferred from A.C.T. to S.A. at the end of 1952 and the Qualifications Committee be transferred from N.S.W. to Queensland. Appreciation of services of proxies and office-bearers in the A.C.T. branch over the past four years was expressed.

The evening session was most enjoyable. Following an excellent dinner and welcome by Dr. R. S. Noble to visitors, Professor E. J. Underwood delivered his presidential address entitled "The Rôle of the Agricultural Scientist in Increasing Food Production in Australia." Before concluding proceedings the president expressed on behalf of the delegates and visiting members warm appreciation of the efforts made on their behalf by the members of the N.S.W. branch.

COUNCIL PROCEEDINGS

Meeting of Proxy Council were held on 19th May and 21st July, 1952.

The period following the Annual General Meeting and the subsequent Council-in-Person meeting has been devoid of new developments and the attention of Council has been focussed on preparations for the 19th General Meeting held in Sydney in association with A.N.Z.A.A.S.

The following matters have received attention:—

Rural Extension Service Report

A collation of Branch opinion on ideal qualities of men engaged in this service and the scope and method of service organization has been made and distributed to branches for checking. It is hoped that a report agreed to by all Branches will emerge. The final phase of this project, namely the ideal form of pre- and in-service training has yet to be attempted.

Affiliate Membership

Articles have been drafted to conform with majority opinion on this somewhat contentious issue and their acceptance or rejection will be decided at the 19th General Meeting.

Institute Opinion

A memorandum on techniques of preparing statements which reflect the considered views of those members most experienced in the field under discussion has been prepared by officers of Council. This may serve as a basis for discussion at the general meeting.

A.I.A.S. Scholarship Scheme

It now appears that, under the requirements for taxation exemption of donors for contributions to this scheme, the funds would have to be allocated to research projects and scholarships for the honours year would not be acceptable. In view of this serious limitation in the field of application and other difficulties the worth of persisting with the scheme will be examined.

A.I.A.S. Access to Arbitration

The progress of the Association of Professional Engineers in securing registration and an award is of interest to the Institute. Arguing by analogy the A.I.A.S. would not be acceptable to the Court and it would be necessary to form a new organization of employee agricultural scientists for registration and an award.

A.I.A.S. Journal

The resignation of Mr. N. M. Tulloh from the editorship was accepted with regret. Council expressed its warm appreciation of the very fine service given by Mr. Tulloh as Honorary Editor and as a small token of that appreciation has presented him with an honorarium of six guineas. Council accepted with pleasure the nomination by the Publications Committee of Mr. J. M. Stevens as Honorary Editor. The action taken by the Publications Committee in distributing copies of the June issue to potential contributors to the Journal was endorsed by Council.

MEMBERSHIP

ADMISSIONS

With the recommendation of the branch submitting the application and the Qualifications Committee, the following applications were approved for **Corporate Membership:**

123rd Council Meeting

Campbell, J. I. (Miss)	Queensland
Champ, B. R.	,,
Haskew, H. C.	,,
Mungomery, W. V.	,,
Ritson, J. B.	,,
Campbell-Smith, L.	South Australia
Beattie, W. A.	Victoria
Edey, T. N.	,,

124th Council Meeting

Bunt, J. S.	New South Wales
Bromell, J. E.	,,
Cook, E. R. H.	,,
McDonald, M. W.	,,
Richards, J. M. (Miss)	,,
Robertson, F. R. (Miss)	,,
Tims, A. V.	,,
Walker, J.	,,
Webster, C. S.	Queensland
Tulloch, D. G.	,,
Patridge, T. B.*	,,
Matheson, W. E.	South Australia
Ward, J. R.	Tasmania
Nihill, F. A.	,,
Macintyre, B. M. (Miss)	Victoria
Naylor, J. B. (Miss)	,,
Rowan, R. H.	,,
Douglas, G. W.	,,
Kohn, G. D.	,,
Hess, P. I.	,,
Marshall, L. D.	,,
McPherson, J. B.	,,
Freer, M.	,,
Parsons, W. T.	,,
Overell, B. T.	,,

*Subject to payment of back dues for two years.

With the recommendation of the branch submitting the application, the following applications were approved for **Student Membership:**—

123rd Council Meeting

Flynn, C.	Queensland
Pollock, J. R.	,,
Young, N. D.*	,,

*Subject to satisfactory completion of application form.

124th Council Meeting

Blanch, N. R.	New South Wales
Campbell, M. H.	„
Lukins, B. G.	„
Baumgartner, P. A.	„
Wheatley, J. M.	„
Sommer, K.	„
Charley, J. L.	„
Greenhalgh, W. J.	„
McMullen, F. C.	„
Gibson, J. B.	„
Whalley, R. D. B.	„
Muirhead, W. A.	„
Gartrell, R. W. B.	„
Johnson, V. M.	„
Morgan, T. R.	„
Gardiner, B. S.	„
Vickery, D. M.	„
Scott, K. J.	„
Swain, F. G.	„
Yu-Sheng, P.	„
Holford, I. C. R.	„
Lynch, B. T.	„
Leadbeater, J.	South Australia
Polomka, P.	„
Parsons, P. A.	„
Sedgley, R. H.	„
Johns, C. R.	„

CANCELLATION OF STUDENT MEMBERSHIP

The following student membership were cancelled on the advice on the recommendation of the branch concerned:—

123rd Council Meeting

Haskew, H. C.	New South Wales
Bollman, F. M.	Queensland
Champ, B. R.	„
Kieseker, F. G.	„
Milford, R.	„
Mungomery, W. V.	„
Ritson, J. B.	„
Tulloch, D. G.	„
Wetherall, R. S.	„
Campbell-Smith, L.	South Australia
Campbell, J. I. (Miss)	Western Australia

124th Council Meeting

Richards, J. M. (Miss)	New South Wales
Robertson, F. R. (Miss)	„
Tims, A. V.	„
McDonald, M. W.	„
Walker, J.	South Australia
Matheson, W. E.	„
Arundell, P.	Victoria
Bromell, J. E.	„
Davidson, B. R.	„
Douglas, G. W.	„
Freer, M.	„
Kohn, G. D.	„
MacDonald, R. H.	„
MacIntyre, B. M. (Miss)	„
McKinley, G. A.	„
Marshall, I. D.	„
Naylor, J. B. (Miss)	„
Osborne, W. B.	„
Parsons, W. T.	„
Rowan, R. H.	„
Hall, G. A.	„
Muirden, B. W.	„

TRANSFERS

The following transfers have been noted:—

Edmonds, A. G.—Victoria to Australian Capital Territory.

Loveday, J.—South Australia to Tasmania.

Wilson, R. W.—New South Wales to Australian Capital Territory.

RESIGNATIONS

The resignations of Mrs. J. Dennis of Victoria and Mr. P. K. Shukla of South Australia were accepted by Council with regret at the 124th Meeting of Council.

BRANCH NOTES

New South Wales

At a general meeting on May 13, Dr. Lincoln Ellison, Fulbright Scholar from the U.S.A., spoke on "The Ecology and Use of Grazing Lands in the Inter-mountain Region of the Western United States." (A summary of a similar talk by Dr. Ellison to the Queensland Branch was included in the June, 1952, issue of the Journal).

On May 30, the main business of a meeting was an address by Mr. C. M. Donald on "Mediterranean Agriculture."

Mr. Donald worked in the Mediterranean area under the auspices of the European Economic Co-operation Organization on a mission which was endeavouring to assist agricultural development.

He described the topography, soils and vegetation of the region. About 70-80 per cent of the country is over 1,500 feet above sea level and the soils are mainly calcareous although light acid soils are important in Portugal. The characteristic vegetation is maquis — a sclerophyllous low scrub. The shrubs are often species of *Quercus*, sometimes only a few inches high and between them grow grasses, medics and many other plants.

Mr. Donald also described the social structure of the Mediterranean countries and showed how it affects agriculture.

He indicated too that cultivation and grazing are quite distinct and there are no sown pastures in the area. Erosion is serious and the

nutritional standard in the livestock industry is often very low.

A series of coloured slides were shown at the end of the address.

At a general meeting on June 24th, Mr. W. M. Carne gave an address entitled "Reminiscences of an Economic Botanist."

Mr. Carne outlined the history of economic botany in Australia. Most of the early workers had come from overseas or were naturalists who had become interested in research or teaching. They were self-taught in many instances and their assistants were men trained on the job. They had to face a wide range of problems.

In 1923, Mr. Carne joined the Western Australian Department of Agriculture as Economic Botanist and Plant Pathologist. Here he was connected with work on such diverse problems as parasitic plants, copper deficiency and other diseases. He then became interested in fruit diseases particularly those of citrus and apples.

His work as Fresh Fruit Officer in the Department of Commerce and Agriculture was concerned mainly with storage and transit disease of home fruits.

Queensland

Four speakers addressed members present at the May meeting.

Dr. H. E. Young, of the Ceylon Rubber Research Scheme, spoke on rubber production in Ceylon, where there are 650,000 acres devoted to the crop. In the course of a survey of cultural and processing operations, Dr. Young stressed the improvement which is being effected by the gradual replacement of seedling trees by superior clones.

Mr. K. J. Hutchinson, Pig Husbandry Officer in the Department of Agriculture and Stock, dealt mainly with research into the pig carcase quality problem, which resolves itself into two parts—the setting up of accurate standards of quality, and the determination of means by which improvement can be effected. Studies in progress on the first aspect are concerned with defining grades on the basis of shoulder fat, loin fat and body length. Investigations into field methods of improving carcase quality were outlined. Backfat thickness was reduced 9 per cent. by including 5-15 per cent. of lucerne chaff in the finishing-off ration to reduce its overall digestibility.

Mr. A. R. Bird, Research Officer in the University Department of Agriculture, gave details of a study of wool production on 200 properties in the Charleville district. The effects of drought and blowfly attack during the survey period were explained, and other factors affecting land use in the area were mentioned.

Mr. C. S. Andrew, of C.S.I.R.O. Division of Plant Industry, summarized the results of pot culture investigations of plant responses to nitrogen and sulphur on a heavy clay soil of the Darling Downs.

The June meeting heard an address on "Some sidelights on Agriculture in Tanganyika", given by Mr. H. Saville, who stressed that the Administration's main aim is to raise the standard of living of the peasant farmers. The first step is to get better land usage by the adoption of soil conservation practices and the provision of more watering points for stock. Rotation cropping and the use of fertilizers will follow this preliminary step. The second main point is to increase output per family by mechanisation of farming.

The Governor of Queensland (Sir John Lavarack) and many leaders in the political, industrial and educational spheres were among the 130 people who attended the public meeting organized by the Queensland Branch in July. An address entitled "Possible Future Developments in Queensland Agriculture" was given by Mr. A. F. Bell, Under Secretary of the Department of Agriculture and Stock.

South Australia

The fascinating story of *Aspergillus niger*, and how it is used in the bio-assay of trace elements, was told to a meeting of this branch on July 18 by C.S.I.R.O. Soil Microbiologist (Dr. R. Swaby). The Lecturer in Plant Ecology at the University of Adelaide (Mr. R. Specht) also addressed the meeting and described the root habits of some native plants in the Upper South-East of South Australia.

Outlining the *Aspergillus niger* work begun in Sydney and continued by the C.S.I.R.O. Soils Division at Adelaide, Dr. Swaby said the interactions of trace elements and micro-organisms could be considered in several ways. Because they were affected by the presence or absence of trace elements, micro-organisms could be used to assay for such elements or their availability in soils. In reverse, micro-organisms, or some of their products could fix or release trace elements in the soil. They could also be used to check on fixation by inorganic substances.

The mould could give clear-cut deficiency symptoms for iron, zinc, manganese, copper and molybedenum and could be made quantitative by comparing the effects of measured amounts of soil and trace element. A scale connecting deficiencies shown by the mould with those shown by herbage plants had now been prepared.

Bio-assay was cheap and quick, Dr. Swaby said. Large numbers of soils could be handled at the one time. The technique was still being developed, but 278 surface soils and 164 subsoils, representing every major soil group in Australia and New Zealand had been investigated, zinc, then copper, had proved the most commonly deficient element in these various soils.

In some deficient soils *Aspergillus* secreted a compound which altered the normal availability of iron and manganese. This effect made *Aspergillus* unreliable when assaying for these substances, but another mould which did not give this distortion had now been developed.

Dr. Swaby outlined experiments which had shown that micro-organisms did not compete with plants for a meagre supply of trace elements in normal surface soils. It had also been demonstrated that organic matter did not lock up trace elements in the soil. The effect of high calcium carbonate content in making some elements less available had also been demonstrated by using *Aspergillus*.

How do perennial plants persist and grow during summer in sandy soils which have dried

out to wilting point well below their apparent root zones? Mr. Specht posed this still unexplained question during his address on the root systems of some native perennials in the Upper South-East, South Australia.

He said root systems varied greatly. In some plants the roots were confined to the top 10-12 inches and in others there was a system of shallow roots with deeper sucker roots down to the clay horizon. The shallow system was dry and senescent during summer but the deeper roots remained succulent and sappy. When rain fell, the surface roots became functional.

In other plants rain interception, which concentrated moisture around the base of the plant, had a hand in shaping the root system. This applied especially to *Banksia ornata.*

In his presidential address to the Institute on May 30, Mr. T. T. Colquhoun outlined the history and probable future of land development in Australia.

Mr. Colquhoun said that land settlement at the present time was largely the outcome of scientific research on soils, plants, and animals. This research had given leads which had helped in the evolution of the most successful methods of development.

War Service Land Settlement had varied greatly from state to state, according to the past history of development. In Western Australia, in the early stages, wheat farms were established on land which had reverted to the Agricultural Bank in depression years. More recently, virgin scrubland in the South-West had been developed.

In Tasmania, emphasis was on virgin land while Victoria and New South Wales concentrated more on the purchase and subdivision of large estates. Queensland had not exploited its potentialities very fully. In South Australia, emphasis was on the development of virgin lands, many of which had only recently been shown to be capable of such treatment.

Tasmania

On the 2nd May, an open general meeting was held in Launceston to hear an address by a former member of the branch, Mr. Bevin. Mr. Bevin was at one time Chief Agronomist of the local Department of Agriculture. He later went to New Zealand as Instructor in Agriculture at Lincoln, a position he left to become Executive Officer of the Meat and Wool Board.

Mr. Bevin spoke on aspects of New Zealand agriculture similar to those of Tasmania.

Two special general meetings of the branch have been held on various aspects of the means of increasing food production in Tasmania. The first was on 30th May when cereals, pigs, and poultry were discussed. At the second on 28th July pastures, fat lambs and beef production and disease problems were the items considered. General discussion followed in both cases.

At these meetings it has been the practice to have guest speakers on those topics, which it was felt, branch members were not sufficiently well informed to present papers. Further meetings are to be held and on completion of the series it is intended to compile the data obtained in order to present the overall picture.

On the 30th June a general meeting of the branch was held at which various matters of branch policy were discussed.

Victoria

A General Meeting of the Branch was held on 4th July, 1952. An amendment to branch by-laws by which the committee is enlarged to include the office of Honorary Recorder was passed. Dr. I. F. Phipps delivered his presidential address in which he gave an extensive review of the contributions of chemistry to agriculture.

On the 1st August a General Meeting was arranged to permit discussion of the Agenda for the 19th Annual General Meeting of the Institute to be held in Sydney. The attendance was however, disappointingly small.

OBITUARY

MR. T. McCARTHY

Died 7th June, 1952, aged 62 years.

It is with keen regret that we place on record the death of Mr. T. McCarthy, formerly Chief Entomologist of the Department of Agriculture of New South Wales.

Born at Sydney, on February 24th, 1890, Mr. McCarthy was one of the first students at Hurlstone Agricultural High School. He entered the Department in October, 1908, as assistant to the late Mr. W. W. Froggatt, and following the death, in 1939, of Mr. W. B. Gurney, who had succeeded Mr. Froggatt, Mr. McCarthy was appointed Chief Entomologist.

He published numbers of papers of economic importance on various insects, being most particularly interested in problems concerning grasshoppers, fruit flies, sheep blowflies, ticks, insect pests of stored products and fumigation methods.

During the years 1914 to 1918 Mr. McCarthy spent much of his time investigating the problems associated with insect damage in wheat stacks, in various parts of the State. From April to November, 1939, he visited the United States of America, Canada and South Africa, where he investigated locust and grasshopper control methods adopted by those countries.

Following the introduction of the Pest Destroyers Act, which operated from September, 1945, Mr. McCarthy was a member, and later Chairman, of the Pest Destroyers Committee.

Mr. McCarthy was a member of the New South Wales Branch of the Institute.

PERSONAL NOTES

Australian Capital Territory

Dr. J. G. Davies Associate Chief of the Division of Plant Industry, C.S.I.R.O., left Australia on July 4th for a period of about ten weeks. The first part of this period was spent in Baluchistan, where Dr. Davies joined a survey team to report on the land use and pasture problems of the country. The survey was under the auspices of F.A.O.

Dr. Davies then proceeded to the United States, where he attended the Sixth International Grassland Congress at State College, Pennsylvania and visited a number of centres in the New England States. He gave a paper at the Congress entitled "The Establishment and Maintenance of Legumes in the Sward."

Mr. T. G. Campbell Research Officer, Division of Entomology, C.S.I.R.O., recently returned to Australia after an absence of some seven weeks. The first four weeks of this period were occupied with an entomological survey of the Cocos-Keeling Islands, carried out on behalf of the Department of Civil Aviation. The object of this survey was to obtain up-to-date information on the insects present in these islands, particularly those of medical, veterinary, agricultural and forestry importance prior to the inauguration of the new air service linking South Africa and Australia by way of Mauritius and Cocos Islands. Following the work at Cocos Islands, Mr. Campbell spent a further two weeks in the Colony of Singapore and Federation of Malaya, working at various research institutions in Singapore and Kuala Lumpur.

Mr. C. S. Christian Officer-in-Charge, Land Research and Regional Survey Section, C.S.I.R.O., recently returned from Northern Australia. While there, Mr. Christian visited the Section's Survey Unit, which this season is completing the field work for the survey of the Ord—Victoria Rivers Region. In company with Messrs. G. A. Stewart and M. Lazarides of the Survey Unit and W. M. Nunn and K. Fitzgerald of the Western Australian Department of Agriculture, an additional preliminary examination was made of potentially irrigable areas in the West Kimberley Division of Western Australia.

Dr. O. H. Frankel Chief of the Division of Plant Industry of C.S.I.R.O., paid a visit to the Field Station of the Land Research and Regional Survey of the C.S.I.R.O. at Katherine, Northern Territory. He also inspected the work in plant introduction and on tobacco conducted there by officers of the Division of Plant Industry.

New South Wales

Dr. R. C. Robertson-Cunninghame has recently returned from Oxford where, during his tenure of a Rhodes Scholarship, he was awarded the degree of Doctor of Philosophy for fundamental research in plant physiology, investigating plant hormones and the toxicity of selective weed-killers.

Advice has been received that *Dr. F. C. Butler* plant pathologist with the New South Wales Department of Agriculture, who has been on leave for about two years as the holder of a Walter and Eliza Hall Scholarship at the University of Cambridge, has been awarded the degree of *Doctor of Philosophy.* Dr. Butler's thesis dealt with studies on take-all, foot rot and other root diseases of wheat.

Mr. W. R. Stern is now located at the C.S.I.R.O. Katherine Research Station.

Dr. R. K. Morton who was recently awarded the degree of Doctor of Philosophy at the University of Cambridge for his work on enzymes, has now returned to Australia. He has joined the staff of the University of Melbourne as Senior Lecturer in Biochemistry.

The Council of the Royal Zoological Society of N.S.W. last year elected *Mr. E. H. Zeck,* Entomologist of the N.S.W. Department of Agriculture, a Fellow of the Society for his contribution over many years to Australian Zoology and for his scientific drawings of insects. Mr. Zeck was president of the Society during the years 1948-49 and 1949-50.

Mr. J. S. Bunt recently returned from Macquarie Island where he spent a period of one year as biologist. He has since addressed a meeting of the N.S.W. Branch on his trip.

Queensland

Mr. T. B. Paltridge Officer-in-Charge of the C.S.I.R.O. Plant and Soils Laboratory at Brisbane left for a period of nine months overseas in May, 1952. He will be concerned with the study of pasture production principally in tropical and sub-tropical areas and will visit Ceylon, India, Pakistan and Africa.

Mr. F. Chippendale has been appointed Senior Soils Technologist in the Division of Plant Industry of the Department of Agriculture and Stock.

Mr. W. J. S. Sloan Assistant Director of Agriculture in the Department of Agriculture and Stock, has been appointed a member of a committee to investigate land development in various parts of Queensland.

Mr. J. F. Miles Senior Research Officer of the Plant Introduction Section, C.S.I.R.O., returned to Australia in June, after a plant-collecting tour extending over many thousand miles. With Mr. C. M. Donald he spent four months in the Mediterranean region collecting pasture plants for the winter-rainfall regions of southern Australia, especially large collections being obtained from Israël and other countries in the eastern mediterranean. Subsequently, Mr. Miles spent a further nine months in Africa ranging from the Sudan and Ethiopia in the north and east, to the Gold Coast and Sierra Leone in the west and to Rhodesia and the Union in the south. The principal objectives here were pasture and crop plants for the tropical and subtropical parts of Australia, but many strains of Veldt grass were collected in the Cape Province. More than 2,000 seed samples have been obtained as a result of this tour and are now being tested at various centres in Australia.

South Australia

Mr. A. J. K. Walker Senior Agronomist in the Department of Agriculture, left for America during July to attend the sixth International Grasslands Congress in Pennsylvania.

Mr. J. B. Doolette has joined the Animal Production Branch of the Department of Agriculture. Mr. Doolette was previously with the Education Department.

Tasmania

Branch numbers have grown to 39 corporate members with two recent admissions and one resignation.

The new members are *Messrs. F. A. Nihill* and *J. R. Ward.* Mr. Nihill is employed by a vegetable canning firm and Mr. Ward has joined the Plant Pathology Division of the Tasmanian Department of Agriculture.

Two members of the branch have recently returned to duty with the Department of Agriculture after a spell of sick leave. They are *Messrs. D. S. Thompson,* Sheep and Wool Officer; and *J. T. Armstrong,* Chief Dairy Officer.

Mr. Berryman, Agronomist, Department of Agriculture, has returned from a visit to New Zealand.

Victoria

Mr. E. Munch-Petersen has been awarded the Gold Medal of the Australian Society of Dairy Technology in recognition of outstanding service to the dairying industry in the technical field during the past ten years. His contributions were primarily in the field of mastitis research and in his pioneering editorship of the Australian Journal of Dairy Technology.

Mr. and Mrs. R. N. Sandiforth have transferred from N.S.W. to Victoria. Mr. Sandiforth has joined the Horticultural Division of the Department of Agriculture and his wife the Milk Laboratory at the Veterinary Research Institute. The position taken by Mrs. Sandiforth is that vacated by *Miss C. E. Edwards* who has left on a visit to England.

Mr. D. N. Kherdekar who spent two years at the School of Agriculture doing research into agricultural engineering, has been appointed by the Central Government of India to a post at the Indian Agricultural Research Institute at New Delhi. His classification is that of an Extension Engineer.

Mr. F. Skaller returned in August to resume charge of the C.S.I.R.O., Poultry Research Centre at Werribee. At the conclusion of his service with F.A.O. in Pakistan, he visited Rome, the U.K. and U.S.A.

Miss U. LeM. Kneebone Assistant Research Agrostologist with the Department of Agriculture, has left for England where she will spend one year at Cambridge, followed by a year gaining post-graduate experience in the U.K. and on the Continent.

BOOK REVIEW

PHYSIOLOGY OF THE FUNGI

By V. G. LILLY and H. L. BARNETT

(*McGraw Hill Book Co., New York,* 1951, 464 *pp*).

There has been for a long time a growing demand for a book which deals with those aspects of physiology which pertain to the fungi. Recently this gap has been filled by the almost simultaneous appearance of several books covering this field.

Lilly and Barnett have provided us with a text which assembles in one place enough of the available knowledge to make it eminently suitable as a general introduction to the study of fungal physiology.

It presents a study of the fungi in relation to their environment and although many mycologists tend to become specialized in their own particular field none can afford to neglect this unifying discipline. The authors devote considerable space to the biochemical background necessary for an understanding of the techniques involved.

The comprehensiveness of the work is indicated by the chapter headings. These include growth, enzymes and enzyme action, carbon sources and utilization, vitamins and growth factors, metabolic products, sporulation, survival and germination of spores, and interaction with other organizms. The authors set themselves the task of presenting the subject with a true mycological background; the sections dealing with the methods for the study of fungi in pure culture, with all its practical aspects, are outstandingly good.

There are some omissions. There is no reference to the more recent techniques centring around shake culture methods and the aeration of culture solutions.

Each chapter carries an extensive bibliography and the student is guided in his choice of further reading, for the more important entries are emphasized by a star.

The book is well planned and beautifully executed and is illustrated by clear figures, plates and graphs. A mass of data has been condensed—no mean task—into a most readable text which provides a balanced introduction to the subject and which should prove a very useful tool in appropriate hands.

ETHEL McLENNAN.

Sulphur and Agriculture

The agricultural scientist is, for obvious reasons, interested in the sulphur situation as this element in its various forms plays an important part in primary as well as in secondary industry. It is an essential component of fertilisers and many agricultural auxiliaries including lime-sulphur sprays, dusting powders, arsenical dips and a variety of chemical products used by the man on the land. It also has a special rôle in the manufacture of such products as weedicides, phenathiazine, DDT, carbon bisulphide, etc. Industrial products such as steel, copper, zinc, rubber, batteries, textiles, galvanised sheeting and wire are also dependent on adequate supplies of sulphur or sulphuric acid.

Following the report of the Inter-Departmental Sulphuric Acid Committee in May, 1950, the Commonwealth Government made a number of far-reaching decisions. The sulphuric acid industry was asked to convert as much as possible of its plant for the use of indigenous sulphide ores by the end of 1953. Toward the end of 1951 the Government decided, as a result of the recommendations of the International Materials Conference Sulphur Committee, that sulphur and sulphuric acid would have to be conserved and placed under allocation in the year 1952/53. To co-ordinate the Government's actions in connection with the conversion of the industry and the allocation of sulphur and its products and to establish a link between the industry and the Commonwealth Government, the Cabinet approved of the appointment of the Sulphuric Acid Executive Committee which has now been functioning for six months.

A number of important developments are now under way which should ensure that Australia's industrial growth and economic position and the increased food production programme is not hampered due to shortages of vital sulphur and its products. The conservation programme came into operation on July 1st, 1952 and with the base year for consumption taken as 1950/51, all increases are being carefully screened to ensure that essential requirements are met as fully as possible and that conservation is being effected.

In Queensland, South Australia and Western Australia considerable increases in the production of pyrite are being programmed to be ready for new or converted acid plants now under construction. This also entails the development of additional rail and handling facilities, together with shipping and harbour services. A large contact sulphuric acid plant and associated equipment has been announced by a new company, Sulphuric Acid Limited, which has been formed by three acid manufacturers in South Australia. This new plant to be erected by the end of 1954 at Port Adelaide will be easily the largest single unit in Australia and it will operate entirely on pyrite mined by the new company, Nairne Pyrites Limited, which has been established by the same three companies in co-operation with the Broken Hill Pty. Co. Ltd. These new ventures, for which the Commonwealth and State Governments have provided a good deal of the financial security, will entail the expenditure of over £3 million and together with the new lead smelter gas acid plant being erected by the Broken Hill Associated Smelters will considerably add to the availability of fertiliser in South Australia.

In New South Wales a new contact sulphuric acid plant and extensions to the superphosphate manufacturing facilities have recently been announced by the Sulphide Corporation at Cockle Creek and Australian Fertilizers Ltd., at Port Kembla have extended their superphosphate plant in anticipation of the completion of a new contact acid plant.

In Western Australia a new acid and superphosphate plant is being erected at Albany as a joint venture by fertiliser manufacturers in co-operation with the State Government. In Victoria, conversion of two large existing acid plants is well under way and by 1954 a considerable proportion of the sulphuric acid will be made from pyrite originating in Tasmania and Queensland. The Electrolytic Zinc Company has also announced details of a large ammonium sulphate plant to be erected at Risdon where superphosphate is already manufactured to satisfy Tasmania's demands. In Queensland, a new contact acid plant is under construction to operate solely on pyrite to take care of additional fertiliser requirements in that State.

F.A.O.—monograph on soil classification and mapping

During the first half of 1952 Dr. C. G. Stephens of the Division of Soils, Commonwealth Scientific and Industrial Research Organization, undertook on behalf of the Food and Agricultural Organization of the United Nations the editing of a monograph on soil classification and mapping. The work was done in Rome at F.A.O. headquarters and in Great Britain and the United States. Various countries which have soil survey organizations supplied material for the monograph and the work largely comprised the integration of this data into a coherent document.

The purpose of the publication is to persuade legislators and administrators in countries which do not have modern soil survey organizations to institute them and so increase efficiency in the use of the land and provide a sound basis for further agricultural development.

Chapter I deals with the purposes and uses of soil classification and mapping including soil management, land settlement, irrigation, salinity, animal and human nutrition, sylviculture, taxation, experiment stations, field trials, soil modification, engineering and scientific usage. Chapter II deals with the administration of soil survey organizations and this is followed by chapters on techniques of soil classification, surveying and mapping and the compilation of soil survey reports. A concluding chapter makes recommen-

dations about the institution of new soil survey organizations, the training of soil scientists and the co-ordination of soil classification.

Argentine Ant

The Argentine ant was first recorded in Melbourne in 1939 and now occupies about 5 aquare miles there. It occupies about thirty square miles in various parts of Western Australia, although it was not recorded there before 1941. The first record in Sydney came in 1950 and the total area in that city is about 1½ square miles. One isolated indoor infestation was discovered in Tasmania in 1951 but was promptly and effectively dealt with.

In the last two years co-operative investigations have been carried out by C.S.I.R.O. Division of Entomology together with the New South Wales Department of Agriculture and the Western Australian Department of Agriculture and Public Health. The main object of these experiments was to improve methods of control, but as the work proceeded, it became evident that a treatment had been developed which could possibly effect complete eradication. This treatment, which involves the spraying of an infested area in a special grid pattern with 2 per cent. chlordane, has been used in trial eradications on certain small areas in both New South Wales and Western Australia. The results have been very promising and it is now considered that a large-scale campaign should be carried out to prove that eradication is a practical possibility.

A recommendation in these terms was made to the Agricultural Council following a recent meeting between entomologists of the C.S.I.R.O. and all States of the Commonwealth. The Agricultural Council agreed that an eradication campaign should be carried out in Sydney and recommended to the Commonwealth and the New South Wales Governments that funds should be provided for this work. It is hoped that this campaign can be carried out during the coming summer.

Land research and regional survey—Papua and New Guinea

The C.S.I.R.O. Land Research and Regional Survey Section is shortly to extend its activities to the territories of Papua and New Guinea. This work is being done at the request of the Department of Territories which is financing the project. The Officer-in-Charge of the Section, Mr. C. S. Christian, is busy selecting a team of specialist officers for this work. The new survey unit will apply the principles of land classification developed in the northern Australian survey but it is expected that field procedure will be very different and that the areas covered each field season will be much smaller. Several overseas appointments have already been made and it is hoped that the unit will be completed in the early part of 1953. Dr. R. D. Hoogland of the Flora Malesiana has been appointed as systematic botanist to the unit. He is expected to arrive in Australia in December after spending short periods in Malaya and at the botanic gardens at Bogor in Indonesia. It is planned that the field arrangements will be in the hands of the New Guinea Administration. The first region to be surveyed is the Buna-Mt. Lamington area.

Southern tablelands pastures linking research and extension

A "conference tour" for research and extension officers concerned with new pasture developments in the southern tablelands of N.S.W. has been arranged by the N.S.W. Department of Agriculture. A period of five days, beginning on October 13, will be spent inspecting field and laboratory experiments carried out by the Department and C.S.I.R.O. and in discussing their significance in this and related areas.

Some spectacular early successes with subterranean-clover and superphosphate were obtained in this district by the Department over 25 years ago. It became apparent, however, that much land on the tablelands was not responding to superphosphate, and about six years ago the C.S.I.R.O. Division of Plant Industry began a study of major and minor elements in field and pot work covering a range of soils. A new wave of interest has followed the discovery that molybdenum and lime must be used to supplement superphosphate on many sites. At a recent meeting of Departmental and C.S.I.R.O. officers held to discuss these results, Mr. A. J. Anderson, of C.S.I.R.O., stated his opinion that enough was now known to enable a good balanced pasture to be grown on almost any soil in the region Some experimental plots have shown an eightfold increase in dry matter, and it is now reasonably certain that the carrying capacity could be at least trebled on several million acres in the southern tablelands district.

It is hoped that representation at the "conference tour" will be wide enough to permit full discussion of further areas that may be involved. An officer of the C.S.I.R.O. Division of Soils will attend to give progress information on a survey now being conducted in the northern portion of the area.

C.S.I.R.O. Agricultural Research Liaison Section is seeking to stimulate this co-operative study of research results relating to a region. Any participation of C.S.I.R.O. officers in the field where applied research and extension merge will be in accordance with the principle that the initiative in the extension application of such work should lie with state extension authorities.

Queensland Pasture Liaison Committee

At a recent meeting in Brisbane, convened by Mr. A. F. Bell, Under Secretary of the Department of Agriculture and Stock, officers of the Department of Agriculture and Stock, Division of Plant Industry of C.S.I.R.O. and the University of Queensland, established a committee to assist pasture research and development in Queensland. It is to be known as the Queensland Pasture Liaison Committee and its aims will be to interchange information on pasture work in progress or projected; to advise as a Committee on pasture work and to co-ordinate the activities of the three bodies. Professor D. A. Herbert was elected Chairman of the Com-

mittee. Other members are Dr. W. A. T. Summerville, Mr. W. J. S. Sloan and Mr. S. Marriott of the Queensland Department of Agriculture and Stock, Dr. J. G. Davies, Mr. T. B. Paltridge and Mr. W. W. Bryan of C.S.I.R.O and Professor L. J. H. Teakle of the University of Queensland. Dr. O. H. Frankel, Chief of the Division of Plant Industry of C.S.I.R.O. attended the first meeting. The Committee plans to hold subsequent meeting in various parts of Queensland where work of interest is in progress.

Melbourne University Agricultural Society: Honorary Life Member, Mr. A. O'Brien

The retirement of Mr. A. O'Brien was recognised at a meeting of the Melbourne University Agricultural Society on 18th July, when he was inducted as Honorary Life Member of the Society and a presentation was made jointly on behalf of the M.U.A.S. and the Institute. Both these bodies have benefited greatly from Mr. O'Brien's active support throughout their existence. Mr. O'Brien has a record of half a century of service to the University and was Secretary of the School of Agriculture from its foundation until 1948.

Refresher course in irrigation at Yanco Experiment Farm

Extension officers from most states will be attending a course on the principles of irrigation of fruit trees and row crops at Yanco Experiment Farm, N.S.W., from 27th October to 7th November, 1952. It is designed to bring together research of C.S.I.R.O. and State organisations and to show its practical application. The course is being organised by the Department of Agriculture, N.S.W., which has appointed a local organising committee with representatives from the Department, the N.S.W. Water Conservation and Irrigation Commission and C.S.I.R.O. Agricultural Research Liaison Section. The convenor is Mr. B. O. French, manager, Yanco Experiment Farm.

The specialist conference on irrigation held at Griffith in 1950 was attended by most Australian research workers concerned with that subject. It was then obvious that many important research results had yet to be applied thoroughly, and some required much further discussion at applied research and extension levels. It is aimed to achieve this by organising the course on the seminar principle supplemented by field trips, demonstrations and some actual research projects.

The subjects to be considered are as follows:—

1. Hydrology and general principles of salting and drainage.
   (a) The influence of irrigation on the hydrologic cycle.
   (b) The general principles of hydrology, salting and drainage.
   (c) Drainage and reclamation practice.
2. Soil properties as a control of irrigation design and practice.
3. Water requirements and root zones of irrigated crops.
4. Methods of applying water and farm design.
5. Irrigation land use and farm management.

A leading paper will begin each session, followed by supporting papers and discussion.

Although the course is primarily for extension people a welcome is extended to officers concerned with research or administration who feel they can profit by or contribute to the proceedings.

Applications should be addressed to the Under Secretary and Director, Department of Agriculture, Box 36, G.P.O., Sydney.

C.S.I.R.O. Translation Section

The following translations have been prepared by the C.S.I.R.O. Translation Section. Copies may be obtained by application to the Senior Information Officer, C.S.I.R.O. Head Office, 314 Albert St., East Melbourne, C.2. A charge of sixpence per page may be made for photocopying.

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LETTER TO THE EDITOR

AN APPARATUS FOR CUTTING AND TREATING PLANT TISSUE IN ONE OPERATION

Sir,

Calvert (this Journal 18, 1952, 105-107), in describing an apparatus for cutting and treating plant tissue in one operation, suggests that the principle could be used in treating eucalypt seedlings and suckers.

An apparatus designed for poisoning eucalypt regrowth was patented by two Queensland graziers, Messrs. W. J. D. and W. B. Shaw in 1937. It consists of a blade mounted on a long wooden handle in such a way that the tool is held in the same manner as a crowbar. The herbicide solution is contained in a knapsack tank of 1-gallon capacity, from which a length of $\frac{1}{4}$-inch diameter rubber conveys the liquid by gravity to a brass tube ($\frac{1}{8}$-inch diameter) which discharges over the hollow-ground upper surface of the blade. The flow of liquid is controlled by a trigger cut-off mounted on the handle. Pressure on the trigger immediately after the stroke is made allows a small quantity of fluid to run into the cut.

The practical advantages are that the operator can stand upright and still chop the tree at ground level, and the actions of chopping and applying poison can be performed in the one operation. Also, herbicide solution can be applied either to chopped-off stumps in the case of small bushes, or to frill cuts made at the base of saplings too large to be conveniently chopped off. It has been used over a period of four years in C.S.I.R.O. tree-killing trials and found quite satisfactory for applying hormone herbicides to small eucalypts. With arsenical solutions, however, there are the usual hazards involved in carrying this chemical in a container on the back and special care must be taken. The apparatus was also used in a trial on brigalow (*Acacia harpophylla* F. Muell.), but with this species it was found unsatisfactory owing to the hardness of the wood and the springy nature of the young saplings.

Yours, etc.,

W. J. Bisset.

Division of Plant Industry,
C.S.I.R.O.,
Cooper Laboratory,
Lawes, Qld.
29.vii.1952.

BOTANY OF SUGAR CANE

By C. VAN DILLEWIJN

(Chronica Botanica Co., Waltham, Mass., U.S.A. and N. H. Seward, Melbourne; 1952, 371 *p.p.*, $6.00).

The production of sugar cane is perhaps one of the most highly organized industries based on any world crop. For many years it has been served by first class research organizations in practically all the major cane growing countries, and yet it is a remarkable fact that to date no modern text book has been published which attempts to collate and present in an orderly manner the mass of data available from innumerable experiments and observations. This lack has now been remedied by Van Dillewijn's "Botany of Sugar Cane". In this book the term Botany is used in its widest sense and it deals comprehensively with Morphology, Anatomy and Physiology.

The first section contains some fifty pages in which the various stem, bud, leaf, inflorescence and root characteristics are detailed and described. Diagrammatic drawings and microphotographic sections are freely reproduced from the world's literature and the author has succeeded in welding the material into a whole which is clear and concise. This is a particularly valuable contribution to sugar literature.

The subsequent chapters dealing with growth, chemical composition, nutrition and their various controlling factors have proved more difficult to handle. This is not unexpected when the nature of the available data is considered and the widely varying conditions of the many countries in which the observations were recorded are taken into account. It is to Van Dillewijn's credit that wherever possible he has summarised the data and indicated its significance. If a reader should suffer some disappointment because of a too generalized attitude on a particular point regarding his own specialty he is at least rewarded with an extensive list of reference to the subject. However, over-simplification is not a general feature of the book and it is felt that the author's method of dealing with sometimes confusing data is entirely commendable. A sidelight on the large number of references is the amazing amount of work (more than six thousand experiments with nitrogen) previously done by Dutch workers in Java; unfortunately the availability of the original literature is limited and therefore the summarised results which are quoted are a valuable feature of the book, particularly to workers in this country.

The publication is printed as "Handbook of Sugar Cane, Volume 1". If subsequent volumes are planned undoubtedly they will be equally welcomed by those concerned with the technical aspects of sugar cane production.

L. G. VALLANCE.

GAZETTER OF AGRICULTURAL AND FORESTRY RESEARCH STATIONS IN THE BRITISH COMMONWEALTH, 1952

(Published by the Commonwealth Agricultural Bureaux. Copies obtainable from the C.A.B. Liaison Officer, C/o C.S.I.R.O., 314 *Albert Street, East Melbourne. Price* 37/6).

The Executive Council of C.A.B. is to be congratulated upon the production of this valuable contribution to the co-ordination of research in British Commonwealth countries and Ireland. It should, and undoubtedly will, find a place on library bookshelves alongside the well-known list of research workers in the British Commonwealth.

For most of the Stations, in addition to their location, crops and lines of research, brief but valuable data are given on climate, altitude and soil types. A notable feature of the book is its splendid indexing. Twenty-five pages are devoted to an index of Research Stations, while the subject index occupies one hundred pages. The Stations are listed under Countries, States and Institutions on a similar pattern to that followed for the list of research workers. The book totals 517 pages and is well printed and bound in cloth.

While this book is obviously an essential reference book for every library serving research workers and teachers in the fields of agriculture and forestry, it may not by its nature and title make such a wide appeal to the general public as some of the technical communications of C.A.B. Nevertheless, there are, to my mind, not a few private collectors who will readily appreciate that these thumb nail records of Research Stations in every Commonwealth country give at the same time, for anyone who reads between the lines, a valuable and most interesting glimpse of the countries themselves.

FRANK M. READ.

THE CLIMATE, GEOLOGY, SOILS and PLANT ECOLOGY OF PORTION OF THE COUNTY OF BUCKINGHAM (NINETY-MILE PLAIN), SOUTH AUSTRALIA

By J. E. COALDRAKE

(*This is C.S.I.R.O. Bulletin, No.* 266, (1952), *obtainable free of charge from the Secretary, C.S.I.R.O.,* 314 *Albert Street, East Melbourne, C.2. Victoria*).

This bulletin present a study of the general environment and soil-vegetation relationships of the north-eastern portion of the Ninety-Mile Plain. Whilst detailed study and mapping have been confined to an area of approximately 1,000 square miles, a preliminary reconaissance survey included the whole of what seems to be a natural climate-soil-vegetation unit. The total area examined is approximately 2,500 square miles and includes portion of the Big Desert in Victoria.

The area lies between the 15 and 20 in. isohyets of mean annual rainfall, and the climate is of "mediterranean" type. Short-term internal rainfall records, together with longer records from stations on the boundary of the area and evidence from the vegetation, have been used to compile a rainfall map with 1 in. isohyets. There is much evidence to indicate that the 17 in. isohyet lies only about 20 miles south of the Pinnaroo railway; this changes materially the previous ideas on rainfall distribution in the region. Temperature and wind date are presented.

It is shown that the soils of the Ninety-Mile Plain are not a homogeneous group. The source of the variation seems to lie in differences in geological history since Pliocene times. On the basis of geological and soil evidence, a line of hills just east of the Adelaide-Melbourne railway has been recognized as a barrier separating areas of different geological history. A complex mixture of sand dune types, ranging from barchanoid dunes to seif dunes, with numerous intermediate types, occurs over the area surveyed.

The area surveyed consists essentially of a vast bed of deltaic clay deposited during the Pleistocene by the predecessor of the present Murray River. This is overlain by an undulating mantle of aeolianitic siliceous sands of recent origin.

Type profiles are described and named, and physical and chemical data on the soils presented. The soils are generally very low in nitrogen, phosphorus, and copper. Their zinc status varies, but appears to be sub-optimal at best. Small areas of laterite are recorded. The clays are all solonized and total soluble salt content may be quite high, though there is no evidence of toxicity symptoms in plants growing on them.

The vegetation is composed chiefly of mallee scrub and heath, in varying degrees of admixture. Communities verging on sclerophyll woodland occur in the southern portion. The major plant communities are described. There is a close correlation between topography, soil type, and the plant communities. The practice of burning carried out over a long period has left the composition of the individual plant communities in a state of flux. The geographical affinities of the flora are indicated.

A tentative division of the whole of the Ninety-Mile Plain into five topography-soil-vegetation suites is suggested, and comparisons have been drawn between these suites. A detailed ecological map has been prepared from interpretation of aerial photographs.

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(*Tait Book Company Ltd.,* 349 *Collins Street, Melbourne,* £3/0/0 *plus postage* 4/1).

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The Catalogue does not contain entries for any journals which commenced publication after 1945. These will be included in a special supplement to be issued shortly, and it is intended to continue issuing supplements from time to time to keep the Catalogue up to date.

The work of compiling and checking the entries extended over several years and was in the hands of Mr. G. R. Pitt, formerly Chief Librarian of the Melbourne Public Library.

POTASH—ITS PRODUCTION AND PLACE IN CROP NUTRITION

By G. A. COWIE, M.A., D.Sc., F.R.I.C.

(*Edward Arnold & Co., London,* 1951. *Illustrated.* 172 *pp.* 21/- *stg. from Publishers*).

For the greater part, English-language text-books have not dealt very fully with potassic fertilisers. The resultant need, felt by workers in many fields, has now been adequately supplied by Dr. Cowie whose books cover the subject most comprehensively.

After dealing with the principal deposits that are now being developed, the author devotes some space to a description of the methods of extraction and manufacture. Of particular interest is the modern flotation-process which makes use of the affinity of the sulphonated aliphatic alcohols or certain amine acetates to separate crystals of potassium chloride from those of sodium chloride without dissolving either. The resultant product, claimed to be almost completely free from tendency to set under humid conditions, would be of great value in sub-tropical Australia.

Details of production and consumption of potassic fertiliser are interesting. Some readers may be surprised to note that, on the authority of the Commonwealth Economic Council (34th Report), the 1948/9 consumption of the main plant foods amounted to over 11,000,000 tons of which N comprised 3.07, P_2O_5 4.97 and K_2O 3.23 million tons.

Laboratory and field workers alike will welcome the chapter dealing with the relationship of potassium to the soil and to the crop, especially the section describing the definitely-established symptoms of potash-deficiency. A further chapter discusses the main methods of diagnosing nutrient (mineral) deficiencies.

The closing chapters are devoted to specific recommendations for various crops under varying conditions. In part this is referred to Britain but a longer section deals with tropical and sub-tropical crops, most of which are grown commercially in Australia, and many Australian authorities are quoted in the bibliography conveniently located at the end of this (and every) chapter.

It cannot be easy to write of any given topic without showing some partiality and descending to propaganda. That Dr. Cowie has done so demonstrates his proper scientific objectivity and his success will make his book of great value to the chemist, the physiologist, the extension worker and even to him for whom they all work, the man-on-the-land.

G. DE V. D.

RAISING SWINE

By G. P. DEYOE and J. L. KRIDER

(*McGraw-Hill Book Co., New York,* 1952, 447 *pp.*, $3.60).

Being essentially American some phases of this work are not applicable to Australian conditions. However, the book has such a wide coverage of sound and practical information on all aspects of the swine industry, that it demands a high place in the literature of any swine-raising country. Scientific training and years of practical experience in handling large numbers of animals give the authors an ideal background for compiling reliable and common-sense advice.

Some of the foodstuffs recommended in the rations are not readily available in Australia, particularly corn which forms the basis of most rations quoted. However as corn is comparable in feeding value to wheat or barley, the tables may be readily adapted to suit the feeds available. The information supplied on trace elements is the most advanced of any so far available and should prove beneficial to all pig raisers.

The type of baconer pig recommended differs somewhat from our recognised standards, animals carrying higher condition than would be appreciated in Australia evidently meeting the American market requirements. Some of the breeds emphasised as suitable for the United States trade are not generally known or recommended in Australia. In other breeds popular in both countries, such as the large White, the descriptions given would not in all instances fit the standard of excellence used for judging in Australia.

All other phases of breeding, feeding, and general husbandry are well and soundly covered with information which would, with few exceptions, be applicable to the industry in any country. The book is easy to read and assimilate and is recommended to all interested in pig raising from the untutored beginner to the field extension worker.

W. S. McAULIFFE.

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